II

ORDOVICIAN FAUNA

By

ARTHUR C. McFARLAN

THE ORDOVICIAN FAUNA OF KENTUCKY

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INTRODUCTION

HIGH BRIDGE SERIES
(M. R. CAMPBELL, 1898)

Massive, cliff-forming limestone of Chazy and Stones River age. Three formations are recognized:

CAMP NELSON (A. M. Miller, 1905, p. 10). Limestone composed of irregular patches and ramifications of granular rock of the Oregon type distributed through a matrix of dense limestone of the Tyrone type, presumably algal in origin. On weathering the surface becomes honeycombed. Fossils are not common, the more characteristic being *Maclurites bigsbyi*, *Escharopora ramosa*, a species of *Rhinidictya*, and various cephalopods.

OREGON—Kentucky River Marble (A. M. Miller, 1905, p. 10). Grey to cream colored, granular, magnesian limestone.

TYRONE—Birdseye Limestone of Linney (A. M. Miller, 1905, p. 10). Dense gray, dove, or cream colored limestone, breaking with conchoidal fracture and with small facets of

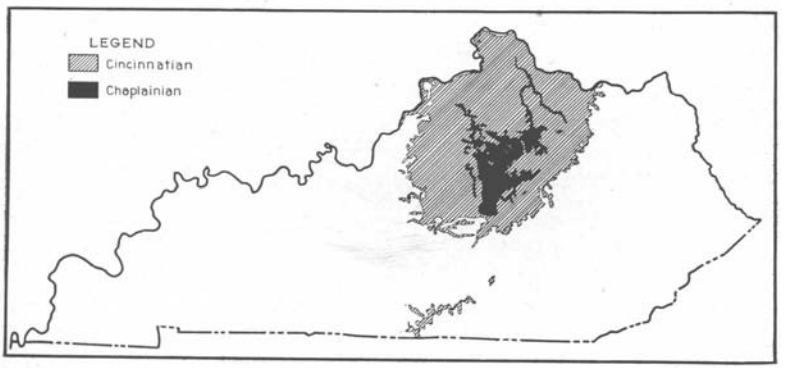


Fig. 25. Map of Kentucky showing outcrop of Ordovician rocks.

coarsely crystalline calcite. On weathering the surface becomes white, in which the darker facets are conspicuous, giving rise to the name Birdseye. A bed of bentonite, a greenish clay, occurs near the top. Fossils are few and include such forms as *Strophomena incurvata,* (see p. 80) *Orthis tricenaria, Leperditia fabulites,* and the cephalopods *Endoceras, Actinoceras,* and *Cameroceras.*

LEXINGTON LIMESTONE (M. R. Campbell, 1898)

This is the Trenton of Kentucky. As originally defined it included the strata between the Tyrone and Flanagan Chert. As later applied by Miller (1905, p. 18) and Foerste everything up to the base of the Cynthiana is included. The series is richly fossiliferous and composed for the most part of thin limestone and shale. The following formations are recognized:

CURDSVILLE (A. M. Miller, 1905, pp. 9, 18). Coarsely crystalline limestone with much chert. Characterictic fossils include *Orthis tricenaria, Dinortliis pectinella, Rhynchotrema trigonale, Streptelasma profundum,* and *Plectambonites curdsvillensis.*

HERMITAGE (E. O. Ulrich, 1903). A more or less siliceous limestone formerly known as the Logana (A. M. Miller, 1905, pp. 9, 18). Characteristic forms are *Dalmanella bassleri, Heterorthis clytie,* and *Prasopora falesi.* Near the top there is commonly a molluscan horizon where *Modiolodon oviformis, Protowarthia obesa, P. pervoluta,* and *Lophospira obliqua* stud the limestone.

JESSAMINE (A. M. Miller, 1919, p. 25). Replacing the name of Wilmore (Nickles, J. M., 1905, p. 15). This is the zone of *Prasopora simulatrix* together with *Dalmanella bassleri, Rhinidictya neglecta, Liospira americana* and *Hebertella frankfortensis.* Over much of Jessamine and Fayette counties, at least, the top of the formation is marked by a siliceous limestone containing a profusion of *Lophospira* and other mollusks.

BENSON (A. F. Foerste, 1913, pp. 365, 389).[1] The association of *Rhynchotrema increbescens* and *Hebertella frank-*

[1] The Bigby formation of Ulrich (Columbia Folio) has been listed as equivalent to the Benson but is regarded as including the Benson, Brannon and Woodburn. The Paris bed (J. M. Nickles, 1905, p. 15) covers the same interval.

fortensis is more or less characteristic, though both occur lower in the column. The upper beds are characterized by the additional occurrence of *Stromatocerium pustulosum, Dinorthis ulrichi, Strophomena vicina,* and *Cyphotrypa frankfortensis.*

BRANNON (A. M. Miller, 1913, p. 324). A fine-grained, siliceous, bouldery or concretionary limestone, with much shale in the lower part. On weathering it gives rise to a conspicuous zone of chert drift and forms the lower part of Campbell's (1898) Flanagan Chert. Fossils are not common except in the shale. The Brannon is the horizon where the remarkable sponges, *Brachiospongia digitata,* and *Pattersonia aurita* are usually found. Of interest is the early occurrence of *Eridotrypa briareus* with *Peronopora milleri.*

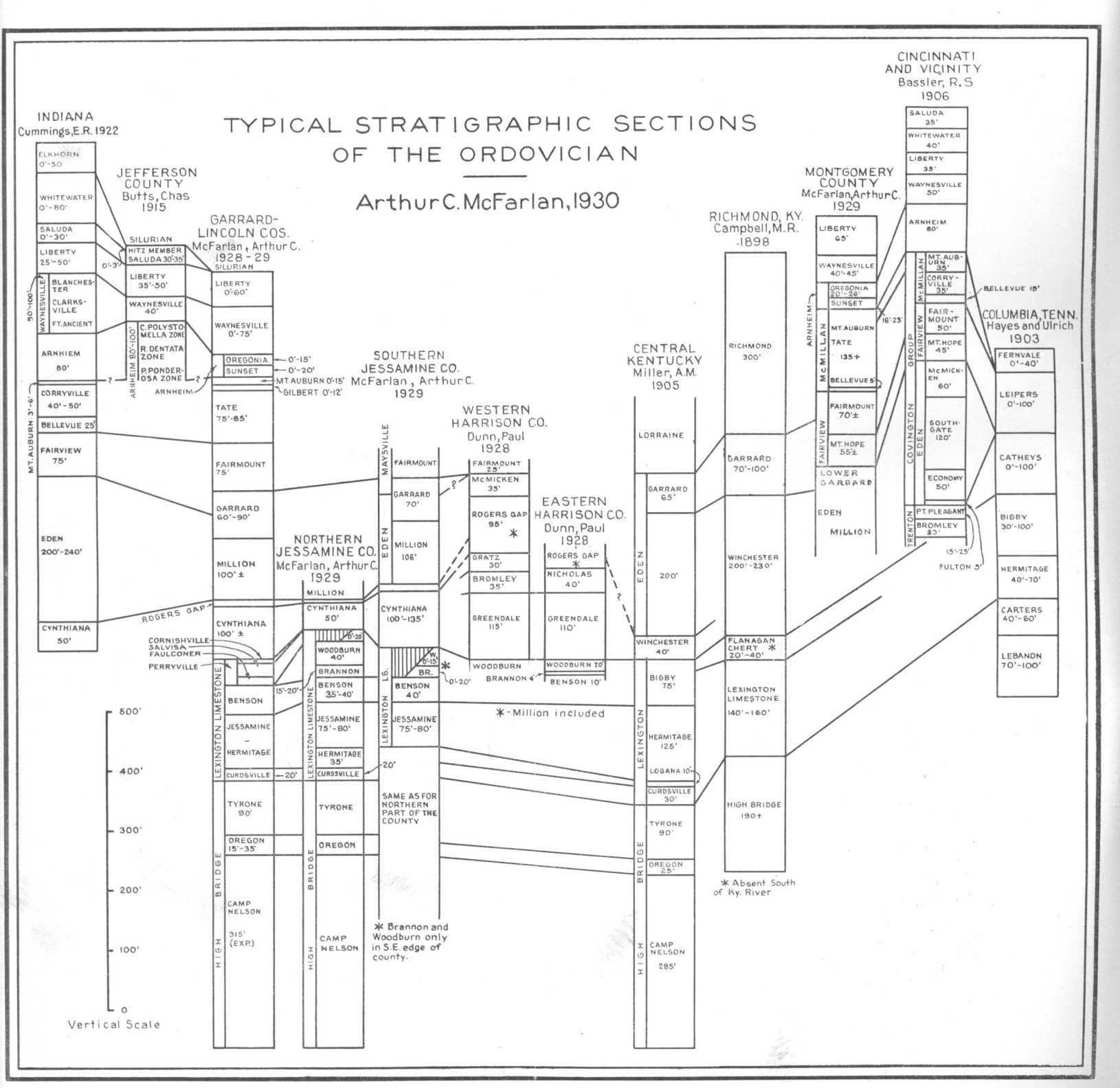
WOODBURN (A. M. Miller, 1913, pp. 326, 327). A crystalline limestone, with unusually high phosphate content. The most useful index fossils are *Columnaria halli,* and C. *alveolata var.* associated with *Platystrophia colbiensis, Constellaria teres* (locally abundant) *Cyclora minuta,* and *Rhynchotrema increbescens.*

PERRYVILLE (J. M. Nickles, 1905, p. 15). This formation is best developed in the southern and western Bluegrass but outliers of both Salvisa and Faulconer occur in the vicinity of Lexington and Paris. Three members are recognized:

FAULCONER (A. F. Foerste, 1912, p. 32). A porous, coarsely crystalline, light gray, massive limestone, in its typical development a crowded mass of gastropod shells, chiefly *Bellerophon troosti, Oxydiscus subacutus,* and *Lophospira medialis.* Silicification of this bed, in weathering, gives rise to the third chert, horizon of the series, a fossiliferous chert.

SALVISA (A. M. Miller, 1913, p. 329). Upper Birdseye limestone of Linney. A compact limestone suggesting the Tyrone, including some of black color. Characteristic fossils include *Isochilina jonesi, Leperditia* (several species), and *Orthorhynchula linneyi.* Locally it is softer and more argillaceous.

CORNISHVILLE (Foerste, 1912, p. 32). Crystalline fossiliferous limestone characterized by the recurrence of the upper Benson fauna. It is restricted to the counties of the southern Bluegrass.


TYPICAL STRATIGRAPHIC SECTIONS
OF THE ORDOVICIAN
Arthur C. McFarlan, 1930
INDIANA
Cummings, E.R. 1922
ELKHORN 0'-50
WHITEWATER 0'-80'
SALUDA 0'-30'
LIBERTY 25'-50'
BLANCHESTER
CLARKSVILLE
FT. ANCIENT
WAYNESVILLE 50'-100'
ARNHEIM 80'
CORRYVILLE 40'-50'
BELLEVUE 25'
MT. AUBURN 3'-6'
FAIRVIEW 75'
EDEN 200'-240'
CYNTHIANA 50'
ROGERS GAP
CORNISHVILLE
SALVISA
FAULCONER
PERRYVILLE
JEFFERSON COUNTY
Butts, Chas
1915
SILURIAN
HITZ MEMBER
SALUDA 30'-35'
0'-3'
LIBERTY 35'-50'
WAYNESVILLE 40'
C. POLYSTOMELLA ZONE
R. DENTATA ZONE
P. PONDEROSA ZONE
ARNHEIM 80'-100'
?
?
GARRARD-LINCOLN COS.
McFarlan, Arthur C.
1928 - 29
SILURIAN
LIBERTY 0'-60'
WAYNESVILLE 0'-75'
OREGONIA 0'-15'
SUNSET 0'-20'
MT. AUBURN 0'-15'
GILBERT 0'-12'
ARNHEIM
TATE 75'-85'
FAIRMOUNT 75'
GARRARD 60'-90'
MILLION 100' ±
CYNTHIANA 100' ±
LEXINGTON LIMESTONE
BENSON
JESSAMINE - HERMITAGE
CURDSVILLE 20'
TYRONE 90'
OREGON 15'-35'
HIGH BRIDGE
CAMP NELSON 315' (EXP.)
SOUTHERN JESSAMINE CO.
McFarlan, Arthur C.
1929
MAYSVILLE
EDEN
LEXINGTON LS.
FAIRMOUNT
GARRARD 70'
MILLION 106'
CYNTHIANA 100'-135'
BR.
BENSON 40'
JESSAMINE 75'-80'
20'
SAME AS FOR NORTHERN PART OF THE COUNTY
WESTERN HARRISON CO.
Dunn, Paul
1928
FAIRMOUNT 25'
McMICKEN 35'
ROGERS GAP 95' *
GRATZ 30'
BROMLEY 35'
GREENDALE 115'
WOODBURN
BRANNON 4'
EASTERN HARRISON CO.
Dunn, Paul
1928
ROGERS GAP *
NICHOLAS 40'
GREENDALE 110'
WOODBURN 20'
BENSON 10'
NORTHERN JESSAMINE CO.
McFarlan, Arthur C.
1929
MILLION
CYNTHIANA 50'
WOODBURN 40'
BRANNON
BENSON 35'-40'
JESSAMINE 75'-80'
HERMITAGE 35'
CURDSVILLE
TYRONE
OREGON
CAMP NELSON
* - Million included
* Brannon and Woodburn only in S.E. edge of county.
CENTRAL KENTUCKY
Miller, A.M.
1905
LORRAINE
EDEN
GARRARD 65'
200'
WINCHESTER 40'
BIGBY 75'
LEXINGTON
HERMITAGE 125'
LOGANA 10'
CURDSVILLE 30'
TYRONE 90'
OREGON 25'
HIGH BRIDGE
CAMP NELSON 285'
RICHMOND, KY.
Campbell, M.R.
1898
RICHMOND 300'
GARRARD 70'-100'
WINCHESTER 200'-230'
FLANAGAN CHERT * 20'-40'
LEXINGTON LIMESTONE 140'-160'
HIGH BRIDGE 190+
* Absent South of Ky. River
MONTGOMERY COUNTY
McFarlan, Arthur C.
1929
LIBERTY 65'
WAYNESVILLE 40'-45'
OREGONIA 20'-26'
SUNSET
ARNHEIM
McMILLAN
MT. AUBURN
TATE 135+
BELLEVUE 5'
16'-23'
FAIRVIEW
FAIRMOUNT 70'±
MT. HOPE 55±
LOWER GARRARD
EDEN
MILLION
CINCINNATI AND VICINITY
Bassler, R.S
1906
SALUDA 35'
WHITEWATER 40'
LIBERTY 35'
WAYNESVILLE 50'
ARNHEIM 80'
McMILLAN
MT. AUBURN 35'
CORRYVILLE 35'
BELLEVUE 15'
FAIRVIEW
FAIRMOUNT 50'
MT. HOPE 45'
McMICKEN 60'
SOUTHGATE 120'
ECONOMY 50'
COVINGTON
EDEN
TRENTON
PT. PLEASANT
BROMLEY 30'
15'-25'
FULTON 5'
COLUMBIA, TENN.
Hayes and Ulrich
1903
FERNVALE 0'-40'
LEIPERS 0'-100'
CATHEYS 0'-100'
BIGBY 30'-100'
HERMITAGE 40'-70'
CARTERS 40'-60'
LEBANON 70'-100'
500'
400'
300'
200'
100'
0
Vertical Scale

As indicated in the Garrard and Jessamine County section the development of the upper Lexington limestone is different in the southern area. In southern Jessamine County, except in the eastern part, the Cynthiana rests directly on the Benson. In central Garrard and northern Lincoln and Boyle counties, the interval between the Jessamine and Perryville beds is occupied by the lower Benson only.

CYNTHIANA

(A. F. Foerste, 1906, pp. 10, 13)

Fossiliferous limestone and shale. Bassler, (1915), recognizes four divisions, the Greendale, Bromley, Gratz, and Rogers Gap members.

GREENDALE (A. F. Foerste, 1909c, p. 295). The characteristic faunal assemblage includes *Cyclonema varicosum, Eridotrypa briareus, Orthorhynchula linneyi, Herbertella maria parkensis, Homotrypa norwoodi, Constellarla emaciata, C. fischeri, Heterotrypa parvulipora, Allonychia flanaganensis, Rafinesquina winchesterensis, Platystrophia colbiensis,* and *Escharopora maculata.* A more richly fossiliferous and rubbly phase occurring in the eastern area of outcrop is known as the Millersburg. The faunal difference is quantitative rather than qualitative. It is in this bed that the precursors of the Fairmount forms are best developed.

BROMLEY (Bassler, 1906, p. 9). The name was given to the thirty feet of drab to blue shales outcropping in the lower part of the river bank at Cincinnati.

GRATZ (undescribed in the literature). The name is taken from a village on the Kentucky River in western Owen County. It consists of a series of rather unfossiliferous shales. Its geographic extent is not known by the writer.

Overlying the Millersburg in Nicholas County is a coarse-grained limestone to which Foerste has given the name Nicholas limestone (A. F. Foerste, 1909, p. 210). At Carlisle a similar limestones overlying the Millersburg contains *Clitambonites.*

ROGERS GAP (A. F. Foerste, 1914, pp. 109-156). The essentials of the type section are as follows:

(a) Lower coarse-grained crinoidal limestone up to eighteen feet thick. This may be the equivalent of the limestone with Clitambonites mentioned above.

(b) Argillaceous strata containing *Eridorthis nicklesi, E. rogersensis,* and *Clitambonites rogersensis* in the lower part.

(c) A gastropod horizon with *Belleophon rogersensis, Tetranota obsoleta, Liospira vitruvia,* and *Lophospira sp.,* a constant and well marked horizon.

(d) Argillaceous strata with *Eridorthis* at top.

(e) 20-25 above (a) an upper coarse grained crinoidal limestone with Eridorthis, which is most common just below it.

(f) Zone of abundant *Plectambonites rugosus* with associated *Strophomena halli* introduced about five feet above (e). This zone (*Plectambonites* does occur lower but not in the same abundance) has been regarded as marking the base of the Eden (Million) in Central Kentucky by Miller and others. It is one of the most conspicuous and consistent horizons throughout the area.

These beds are of wide extent in Central Kentucky. *Eridorthis* has been identified along the Ohio River at a level well below the Fulton layer (A. F. Foerste, 1914, pp. 119, 120), also in the lower Economy at several localities in that region (Foerste, 1909, p. 294). The stratigraphic relationships of this bed are not well known.

EDEN
(E. ORTON, 1873, pp. 370, 371)

At Cincinnati four divisions are recognized:

FULTON (A. F. Foerste, 1905, p. 151). Shales characterized by *Triarthus becki, Leptobolis insignis, Plectambonites plicatellus,* and *Merocrinus curtus.*

ECONOMY (R. S. Bassler, 1906, pp. 8-10). The *Aspidopora newberryi* zone of Nickles. It is characterized by *Coeloclema commune, Crepipora venusta,* and several species of *Aspidopora* (R. S. Bassler, 1903, p. 9).

SOUTHGATE (Bassler, ibid). The zone of *Ctenobolbina ciliata., Aspidorpora eccentrica* and *Batostoma jamesi.* Cum-

mings and Galloway regard *Climacograptus typicalis* and *Bythocypris cylindrica* as characteristic in the Tanners Creek section.

MCMICKEN (Bassler, ibid). The zone of *Dekayella ulrichi* of Nickles. Limestone is a more conspicuous element than in the lower members. The typical fauna includes *D. ulrichi, Coeloclema commune, C. alternatum, Batostoma Jamesi, B. implicatum,* and *Hallopora onealli.*

In Central Kentucky the Eden is divided into two members, the Million (J. M. Nickles, 1905, p. 25), and the overlying Paint Lick (A, F. Foerste, 1909c, 293) constituting the lower, massive part of the Garrard sandstone of Campbell (1898). The Paint Lick is quite barren of fossils. Among the more characteristic forms of Million are *Plectambonites rugosus, Dalmanella multisecta,* and *Ectenocrinus simplex.* The base is marked by the appearance in great numbers, commonly in a crinoidal limestone, of *Plectambonites rugosus* and *Hallopora onealli.* In some sections, at least, *D. multisecta* is introduced in equally large numbers ten or fifteen feet lower.

MAYSVILLE

(A. F. Foerste, 1905, pp. 149-52)

FAIRVIEW (R, S. Bassler, 1906, p. 10). This is the *Plectorthis plicatella* zone of Cumings and Galloway (1913, p. 2) and includes Nickles' Mt. Hope or *Amplexopora septosa* beds (1902, p. 76) and his Fairmont or *Dekayia aspera* beds (ibid, p. 78). The faunal change from the McMicken is not abrupt. Common forms are *Plectorthis plicatella, Platystrophia laticosta, Amplexopora septosa, Batostoma implicatum, Dekayia aspera, Eschapora falciformis, E. pavonia, Hallopora andrewsi, H. dalei, Heterotrypa subfondosa, Homotrypa curvata, Constellaria florida,* and *Peronopora vera.*

MT. HOPE. This formation overlies the *Dekayella ulrichi* zone and is characterized by the introduction of a rich bryozoan fauna and of *Platystrophia. Plectorthis neglecta* is regarded as characteristic. In Central Kentucky this horizon is represented in the upper Garrard. *Strophomena maysvillensis* occurs in moderate numbers.

FAIRMOUNT. At Cincinnati the Fairmount is marked at its base by the *Strophomena Planoconvex* zone, a limited horizon where this species occurs in great numbers. The occurrence of several species of *Plectorthis, P. plicatella, P. fissicosta,* and *P. aequivalvis,* is characteristic. In the central and southern Bluegrass the fauna is that of the Maury phase (A. F. Foerste, 1912, p. 19). The base is marked by a profusion of *Strophomena maysvillensis* and *Constellaria florida.* Other characteristic forms are *Orthorynchula linneyi* (upper), *Escharopora hilli, Cyrtoceras valandinghami, Platystrophia ponderosa* (lowest occurrence), *Hallopora dalei, Monticulipora mammulata, and Homotrypa cincinnatiensis.*

McMillan

(R. S. Bassler, 1906, p. 10)

This series includes the Bellevue, Corryville and Mt. Auburn formations as exposed in the region around Cincinnati. In the southern Bluegrass it is represented by the Tate, Gilbert and Mt. Auburn, with the Bellevue appearing as the lower Tate farther north.

BELLEVUE, the *Monticulipora molesta* beds of Nickles (1902, p. 82) and the *Rafinesquina ponderosa* zone of Cumings and Galloway (1913, p. 2). This highly fossiliferous zone of thin bedded limestone extends south into Montgomery County on the east and Shelby County on the west.

CORRYVILLE, the *Chiloporella nicholsoni* (*C. flabellata*) zone of Nickles, (1902, p. 83). Other more or less characteristic fossils are *Bythorpora gracilis, Rafinesquina fracta, Amplexopora filiasa, Hallopora andrewsi, Dekayia appressa,* and *Heterotrypa paupera.*

MT. AUBURN, the *Platystrophia lynx* beds of Nickles (ibid., p. 85). *Platystrophia ponderosa auburnensis* is characteristic. Associated forms are *Coeloclema oweni* and *Homtrypa pulchra.* In the southern Bluegrass it is a similarly highly fossiliferous rubbly limestone with *Platystrophia ponderosa* and *Heterospongia subramosa* common. A third common species is *Amplexopora robusta.* Lithologically it is well marked, resting on the dense limestone of the Gilbert, and beneath the non-fossiliferous Sunset.

HARMON (Cumings and Galloway, 1913, pp. 2, 7), referred to as the *Rafinesquina fracta* zone, including the Corryville, Mt. Auburn, and Arnheim formations of Indiana. The most common fossils are *R. fracta* and *Hallopora ramosa.* Characteristic forms according to Cumings and Galloway are *Atactoporella ortoni, Coeloclema oweni, Homotrypa pulchra,* and *Dinorthis retrorsa* (*carleyi*).

TATE (A. F. Foerste, 1912, p. 18). A non-fossiliferous, gray shale and shaly limestone section of the southern Bluegrass. Northward on the eastward flank of the arch fossiliferous zones become more common and in northern Clark and Montgomery counties it is abundantly fossiliferous with *Platystrophia ponderosa, Amplexopora robusta,* and *Cyphotrypa clarksvillensis* (cc.). Here it overlies the Bellevue.

GILBERT (Foerste, ibid.). A zone of dove to gray, fine-grained to dense, hard limestone restricted to the southern Bluegrass. It grades into the Mt. Auburn. *Platystrophia ponderosa* and *Lophospira bowdeni* are common. The Tate and Gilbert of Lincoln, Garrard, etc., counties together fill the interval of the Bellevue and Corryville to the north.

RICHMOND

(Winchell and Ulrich, 1897, p. 53, formerly known as the Lebanon beds Orton, 1873, p. 371)

The Richmond has customarily been recognized as beginning with the Arnheim though the latter had originally been classified with the Maysville and was again referred to it in 1913 by Cumings and Galloway (1913, pp. 2, 8).

ARNHEIM (A. F. Foerste, 1905, p. 150), the Warren beds of Nickles (1902, p. 86). At the type locality in Brown County, Ohio, he placed the top at the lumpy limestone containing *Strophomena concordensis.* In the eastern and southern area of out-crop two divisions are recognized:

SUNSET (A. F. Foerste, 1910, p. 18). A relatively non-fossiliferous argillaceous series, comparable to the Tate and Waynesville, sometimes dolomitic. Throughout the region of

Garrard, Lincoln, Clark, and Montgomery counties it is capped by a few feet of hard limestone, mostly of the Gilbert type, in some layers of which ostracods are very common. Northward in Ohio the Sunset becomes quite fossiliferous.

OREGONIA (A. F. Foerste, ibid.). A highly fossiliferous, rubbly limestone, in which the characteristic Richmond brachiopods *Rynchotrema dentatum* (*var. arnheimensis*), *Leptaena richmondensis* (*var. precursor*), and *Dinorthis carleyi* (rare in Kentucky) are introduced. The association of any one of these species with Platystrophia ponderosa (upper limit of range) is regarded as diagnostic. *Heterospongia knotti* is rather characteristic in the area between Lincoln and Marion counties. Over much of this area the top is marked by about two feet of light colored shale, full of slender bryozoa, including a form resembling *Hallopora dalei* and a *Homotrypa* (see p. 93).

In Jefferson County which may be regarded as typical of the western area, Butts (1915, pp. 41-49) has divided the Arnheim into three members:

(a) *Platystrophia ponderosa* zone. According to Butts it rests disconformably on the Bellevue at Sulphur in Henry County and at Madison, Indiana. McEwan (1920) has shown the presence of the Corryville and Mount Auburn in the latter section.

(b) *Rhynchotrea dentatum* zone (assoc. *L. richmondensis).*

(c) *Constellaria polystomella* zone. Other common fossils are *Anomalodonta gigantea, Homotrypa bassleri, Hallopora subnodosa,* and *Platystrophia cypha. Platystrophia ponderosa* ranges through all these zones, *Dinorthis carleyi* is rare in both (a) and (c), and *Cyclonema bilix var. fluctuatum* occurs in all three.

WAYNESVILLE (Nickles, J. M., 1903, p. 205). In 1910 Cumings used the term *Dalmanella meeki zone.* Three members are recognized (Foerste, A. F., 1909, pp. 291-292) in Ohio.

FORT ANCIENT. Characterized by the abundance of Dalmanella meeki and absence of other characteristic Richmond brachiopods and corals. *Anomalodonta gigantea, Modiolopsis concentrica, M. pholadiformis, Opisthoptera fissicosta,* and *Pterinea demissa* are common. The top is marked by the *Orthoceras fosteri (duseri)* bed.

CLARKSVILLE. This member includes all strata up to the lower *Hebertella insculpta* horizon (Austin, G. M., 1927, includes the *Hebertella insculpta* zone in the Clarksville.). *Streptelasma vagans, Plectambonites rugosus, Strophomena planumbona, S. sulcata, Rhychotrema capax,* and *Leptaena richmondensis* are common. It may be traced southward into Fleming County, Kentucky, (Foerste) but is not recognized in the western area of out-crop.

BLANCHESTER. Terminated by the upper *Hebertella insculpta* horizon which has commonly been recognized as marking the basal Liberty but has more recently been included in the Waynesville (A. F. Foerste, 1909, p. 290). It has the richest fauna of the Waynesville and may be traced south into Bath County. *Strophomena nutans, S. neglecta,* and *S. vetusta* form a well-marked horizon in the middle. *Leptaena richmondensis, Rhynchotrema capax, Platystrophia clarksvillensis,* and *P. cumingsi* are common.

In Jefferson and adjoining counties the Waynesville is a series of shales and shaly limestones, the base marked by the occurrence of *Columnaria alveolata* and *Tetradium minus* (Fisherville coral reef of Foerste, 1909, p. 29). Above is a zone of shale with *Cyphotrypa clarkvillensis* (cc.). The rest of the formation is sparingly fossiliferous with *C. clarksvillensis* and *Zygospira kentuckiensis* characteristic.

Across the southern Bluegrass the Waynesville is almost void of fossils but, becomes fossiliferous again to the north in Montgomery County.

Because of the close faunal relationship between the Waynesville and Liberty Foerste (1912, p. 22) proposed the name Laughery formation for the combined sequence.

LIBERTY (Nickles, 1903, p. 207)—The *Strophomena-Rhynchotrema* bed of Cumings (1900), and *Strophomena planumbona* zone of Cumings and Galloway (1913, p. 2). Over most

of its area of outcrop in Kentucky the base is marked by a coral reef, the Bardstown reef of Foerste (1909, p. 290) composed of *Columnaria alveolata, C. vacua, Tetradium minus, Calapoecia cribriformis,* and the associated *Beatricia undulata,* and *B. nodulifera.* It may be traced southward into Lincoln County on the one side, and Marion County on the other. The Liberty is missing along the axis of the arch. The more characteristic species include *Dinorthis subquadrata, Plectambonites rugosus, Rhynchotrema capax, Strophomena planumbona, Streptelasma rusticum, Rhombotrypa quadrata, R. subquadrata, Protarea richmondensis,* and *Homotrypa austini.* In the region between Lincoln and Montgomery counties, at least, the basal reef is often missing and the bottom of the formation is marked by a massive dolomitic limestone. The presence of *Hebertella insculpta* would place this bed at the top of the Waynesville. The rest of the limestone over this same region is more or less dolomitic and fossils not well preserved. *Strophomena sulcata, Bythopora meeki, B. delicatula,* and occasionally *R. capax* are present. The upper part of these beds may include the Whitewater.

SALUDA—WHITEWATER

The SALUDA (A. F. Foerste, 1902, p. 369) is a dolomitic limestone, scantily fossiliferous except for an upper member, the Hitz limestone (A. F. Foerste, 1903b, p. 347), earlier designated as the *Murchisonia hammeli bed* (A. F. Foerste, 1896, pp. 218-222) which contains a Whitewater fauna. In the lower part of the formation, a few feet above the base, a reef of *Columnaria* and *Tetradium,* similar to the lower reefs is a characteristic horizon marker. This is the Madison coral reef of Foerste, (1909, p. 290).

The WHITEWATER (J. M. Nickles, 1903, p. 208) and Saluda are contemporaneous phases of sedimentation, the former wedging out and overlapping the Saluda to the south where it is represented by the Hitz member, the latter (Saluda) thinning northward. The Whitewater may be represented in the upper part of the "Liberty" on the eastern flank. The fauna is much like that of the Liberty, the bryozoa, *Batostoma variable, Homotrypa nicklesi* and *H. nitida* being restricted to it. Other common forms include *Bythopora delicatula, Homotrypa constel-*

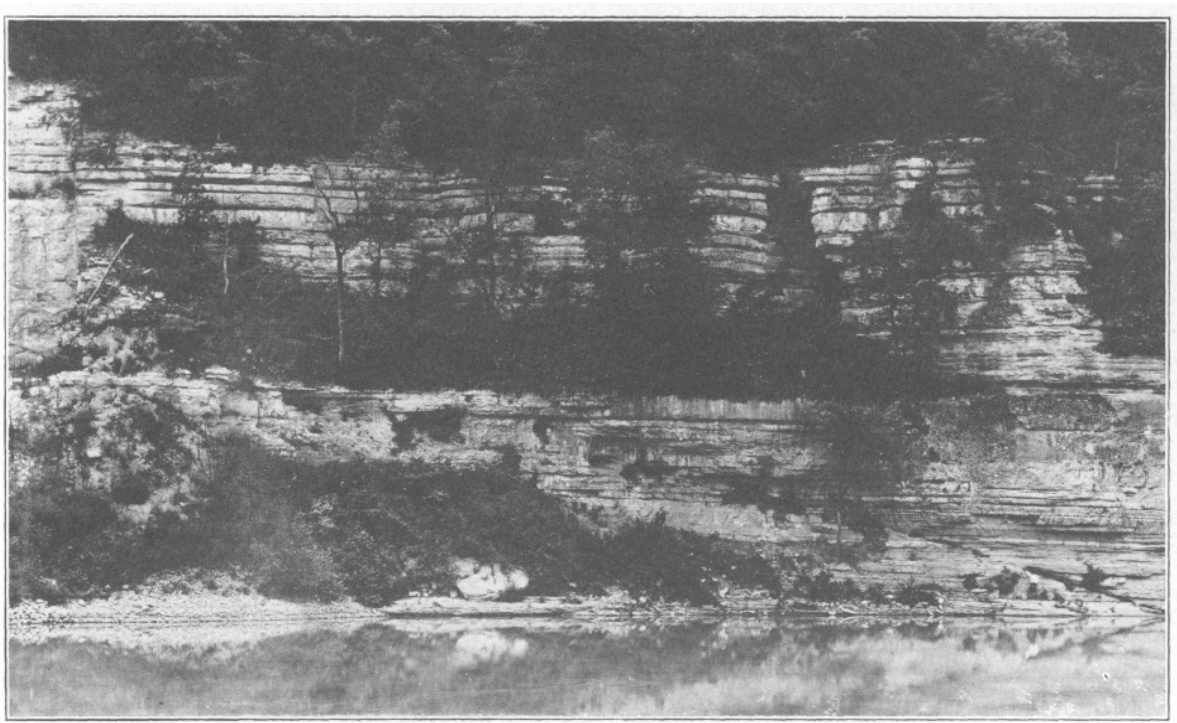


Photo W. R. Jillson

HIGH BRIDGE AND LEXINGTON LIMESTONES AT BOONESBORO

These massive divisions of the Ordovician are markedly faulted at this point on the Kentucky River. To gain a sense of the really magnificent proportions of this clifted exposure note the figure of a man in the lower right hand corner. His hand is resting on the plane of fault displacement.

DESCRIPTION OF SPECIES

FAMILY DYSTACTOSPONGIDAE

GENUS HETEROSPONGIA ULRICH

Sponge sublobate or of compressed branches, surface showing mouths of branching, more or less tortuous canals which curve outward from the center. A few oscula present, distinguished by their larger size and surrounded by radiating channels. Sponge skeleton between the canals of variable thickness, sometimes appearing nearly solid, at others of loosely interwoven spicules.

HETEROSPONGIA SUBRAMOSA ULRICH Pl. XII, figs. 5-6; Pl. XIV, fig. 13

Sponge subramose, of cylindrical or compressed branches up to 30 mm. or more in width. Its general features are shown in the accompanying figures.

This species has its best development in the Mount Auburn of the southern Bluegrass, is common in the Oregonia and is locally common in the Fairmount and Waynesville.

HETEROSPONGIA KNOTTI. ULRICH
Pl. XIV, fig. 8

Distinguished from H. subramosa by the relatively small apertures, (6-8 in 5 mm. instead of about 5) and the presence of oscula scattered over the surface at intervals of 8-20 mm.

Common in the Arnheim of the southern Bluegrass, also in the Mount Auburn at Burdett Knob (Garrard County). Foerste mentions its occurrence in the Liberty near Lebanon. The specimen figured is exceptionally large.

FAMILY BRACHIOSPONGIDAE

GENUS BRACHIOSPONGIA MARSH

Sponge consisting of a hollow central body, circular or elliptical, with an opening on the summit, continuous radially with a number of downward curving, hollow, distally closed arms.

BRACHIOSPONGIA DIGITATA. OWEN

Pl. III, fig. 9; Pl. LV, figs. 1-2

This species has from eight to twelve arms. In the figured specimen the diameter is about 23 cm., that of the central body 14½ cm., osculum 4½ cm., height, of collar about osculum 2-2½ cm. Length of arms 5½ cm.

This remarkable form is found in the Brannon of Franklin County where it is common at two localities, unknown elsewhere. The writer has a specimen from the Curdsville, possibly basal Hermitage, from a few miles east of Nicholasville along the West Hickman Fault zone. It is rather small, with seven arms, and noteworthy because of the unsilicified condition. This has made possible the preparation of sections showing the characteristic hexactinellid spicules which are represented by calcareous casts (see Pl. IV, fig. 2). A silicified specimen from the chert waste near Dix River Dam may come from the Curdsville also. Other species have been described from the Mt.Hope and Liberty.

FAMILY PATTERSONIIDAE

GENUS PATTERSONIA (MILLER)

PATTERSONIA AURITA. (BEECHER)

Pl. III, fig. 10

This species was originally described under the generic designation of Strobilospongia. Its general features are shown in the accompanying figure. According to Beecher (1889 p. 15) the spicular structure "so far as observed" agrees with that of Brachiospongia.

The type is from the *Brachiospongia* bed (Brannon) on Benson Creek in Franklin County. Fragments of the basalia are quite common in the Brannon chert drift in the central Bluegrass, some coming from above in the Woodburn. The only locality where good specimens may be obtained so far as the writer knows, is on the farm of Dr. A. M. Peter in northern Fayette County.

FAMILY PROTOSPONGIDAE

GENUS HINDIA DUNCAN

Free, spheroidal characterized by a series of minute bifurcating canals radiating from the center and opening on the surface.

HINDIA PARVA. ULRICH
Pl. IV, fig. 7

A very common species of the Trenton varying from 5-10 mm., in diameter. They are most common at the Brannon horizon.

PHYLUM COELENTERATA

CLASS HYDROZOA FAMILY BEATRICEIDAE

GENUS BEATRICEA

Cylindrical or angulated stems, often fluted, and ranging in size to over ten feet in length and a foot in diameter. A central tube with cystose tabulae and a peripheral vescicular structure characterize the fossil. (Grabau and Shimer 1909 pp. 46, 47.)

BEATRICEA UNDULATA. BILLINGS

Up to 6cm. in diameter, characterized by longitudinal, rounded ridges separated by broad shallow grooves. These are not always continuous and often show a spiral twist.

Characteristic of the basal Liberty. In southern Indiana it has also been identified from just above the *Columnaria* reef of the basal Saluda.

BEATRICEA NODULIFERA. FOERSTE

Distinguished by a nodulose surface, the nodes more or less irregularly distributed but tending toward an arrangement in somewhat spiral vertical rows. *B. nodulifera intermedia* (PI. XVI, fig. 1) is intcrmed ate in character.

An associate of *B. undulata* in the basal Liberty. It may be a synonym of *B. nodulosa* Billings.

FAMILY LABECHIIDAE

GENUS STROMATOCERIUM

"Coenosteum massive, of dense, thick horizontal and concentric discontinuous laminae, separated by very narrow interspaces. No radial pillars. Small vertical tubes penetrate the several laminae, connecting interlaminar spaces. No astrorhizae." (Grabau and Shimer 1909, p. 46).

STROMATOCERIUM PUSTULOSM. (STAFFORD)

This very common Ordovician species forms masses from a few inches in diameter up to three or four feet, the surface characteristically pustulose. The base is usually concave with irregular, concentrically wrinkled epitheca. In all specimens observed by the writer, other than those which had been silicified, the material was recrystallized.

This form, possibly including some which are specifically distinct, occurs at a number of horizons in the local Ordovician, including the uppermost Bensons (cc). Woodburn (r), Cynthiana (cc), Mount Auburn (c), Oregonia member of the Arnheim (c), and Liberty.

CLASS GRAPTOLITOIDEA

FAMILY DIPLOGRAPTIDAE

GENUS CLIMACOGRAPTUS. HALL

The principal character of Climacograptus is the peculiar geniculation of the thecae which, in their proximal part, are attached parallel to the axis thereby placing the aperture into a more or less deep transverse excavation between two successive thecae. (Ruedemann 1908, p. 400)

CLIMACOGRAPTUS TYPICALIS. HALL

Rhabdosome long and narrow, characterized by the slender, whip-like sicular end, the very small overlap of the early thecae, and the aspect of the thecae in the mature part of the rhabdosome, their distal free parts standing out as a series of squares from the broad median part of the lateral face. A characteristic Eden species.

CLASS ANTHOZOA

FAMILY ZAPHRENTIDAE

GENUS STREPTELASMA. HALL

Corallum turbinate, often curved. Septa alternately long and short, the edges of the longer twisted together at the center. Tabulae few or absent. Tetrameral arrangement well shown externally with removal of epitheca.

STREPTELASMA PROFUNDUM. (OWEN)

Corallum several cm. in length characterized by the great depth of the calyx, extending nearly to the base of the coral.

Septa relatively few, (60-74 in mature specimens) not twisted at the center, and with crennulated margins. Primary septa strong, with three pseudo-fosulae, and double cardinal fossula, divided by the cardinal septum. Tyrone and Curdsville.

STREPTELASMA RUSTICUM BILLINGS

Corallum straight or slightly curved with strong annulated epitheca. Length up to 10 cm., or more, diameter 2-4 cm., depth of calyx 1-1½ cm. Septa one hundred or more alternating in size, the larger strongly twisted at the center.

Common in the Liberty, also in the Blanchester member of the Waynesville of Ohio, Indiana and Northern Kentucky, and the Whitewater of Ohio and Indiana.

STREPTELASMA DIVARICANS. NICHOLSON

A small commonly attached species, usually occurring in clusters. Length 15-20 mm., septa 58-62, alternately large and small, strongly twisted at the center. Calyx deep. No fossula.

Range and distribution essentially the same as S. rusticum. Common also in the Saluda.

FAMILY CYATHOPHYLLIDAE

GENUS COLUMNARIA. GOLDFUSS

Corallum massive of prismatic contiguous corallites with more or less developed septa. Walls thin, imperforate. Tabulae numerous.

COLUMNARIA HALLI. NICHOLSON PL IV, fig. 5

Distinguished from *C. vacua* by the smaller corallites (Foerste 1909 p. 313). Specimens from this lower horizon have coralites varying from 2-3 mm. to 3-4 mm. in diameter, a conspicuous feature being the great irregularity in size within the same corallum. This last feature may be diagnostic, tho a feature of the smaller coralla with the rapidly diverging corrallites.

Very common in the Woodburn, less so in the Cynthiana.

COLUMNARIA ALVEOLATA. GOLDFUSS
Pl. IV, fig. __, Pl. XVI, fig. 13

Massive coralla attaining a diameter of several feet. Corallites hexagonal or pentagons, of unequal size, the larger averaging 4 mm. in diameter. Septa alternately large and small, the latter rudimentary, the former extending almost if not quite to the center, this feature characterizing the species. Twelve to 15 or more septa in each series. Tabulae spaced about 1 mm. apart.

Foerste's variety *interventa* from the Woodburn is distinguished by the great inequality in size of the corallites within the same corallum. (see above). It occurs also in the Cynthiana.

This species forms a conspicuous reef (Bardstown reef) in the basal Liberty. In Southern Indiana a similar reef occurs in the basal Saluda (Madison reef), another occurs in the basal Waynesville (Fisherville reef). It is occasionally found elsewhere in the Richmond.

COLUMNARIA VACUA. FOERSTE

An assocate of *C. alveolata,* distinguished by the meagre development of septa, which occur as sharp striae. Corallites usually about 4 mm. in diameter.

FAMILY HELIOLITIDAE

GENUS PROTAREA. E. and H.

Thin incrusting coralla. Corallites polygonal with shallow calices. Septa 12.

PROTAREA RICHMONDENSIS. FOERSTE
Pl. XVI, fig. 12

Corallum an incrusting layer about 2 mm. thick. Corallites polygonal, of about equal size, 4 in 5 mm. Septa 12, scarcely reaching half the distance to the center. In some associated specimens the septa are replaced by papillae giving the appearance of a *Protares* incrusted by *Labechia* papillata.

P. richmondensis makes its appearance in the Clarksville member of the Waynesville in Ohio and is common in both Liberty and Whitewater. In Kentucky it is characteristic of the Liberty on both sides of the arch.

FAMILY FAVOSITIDAE

GENUS CALAPOECIA. BILLINGS

Septa well developed tho short. Mural pores large, arranged in vertical rows between the septa.

CALAPOECIA CRIBRIFORMIS. NICHOLSON

Pl. XVI, fig. 2

Corallum massive. Distributed between the normal corallites with diameter of 2-3 mm., a variable number of smaller corallites, their number determining the shape of the larger ones. Septa as strong vertical ridges extending only a short distance into the cavity, 20-24 in number. Mural pores oval, large, in rows between the septa, 5-6 in 5 mm., longitudinal interspaces less than half the greater diameter of the pore. Tabule thin, a tube diameter or less apart.

Common in and rather characteristic of the Liberty, also present occasionally at other Richmond horizons.

FAMILY CHAETETIDAE

GENUS TETRADIUM. DANA

Massive coralla of long slender prismatic corallites, quadrangular or petaloid in section. Four primary septa and numerous tabulae.

TETRADIUM FIBRATUM. SAFFORD

Pl. V, fig. 13

Septa nearly reaching the center. Diameter of corallites about .04". (See below.)

According to Bassler (1915) this is the Trenton-Maysville form.

TETRADIUM APPROXIMATUM. ULRICH

This is the species commonly referred to as T. minus. It is distinguished from *T. fibratum* in the smaller size of the corallites which are described as 1/3-1/4 line in diameter, i. e. 0.02”-0.03”. It is listed by Bassler as from the Richmond. Foerste notes it also in the Maysville. Measurements on specimens from the Waynesville and Liberty show them to have 3-4 corallites in 2 mm. There is considerable variation within the corallum and some of the larger measure 2½ in 2 mm. Specimens from the

Cynthiana, Lexington, and Tyrone commonly measure 1½-2 in 2 mm., rarely the smaller individuals in a corallum as high as 3 in the same distance. No specimens from the Maysville were available. The finer tubed forms of the Richmond constitute the *T. approximatum,* the earlier coarser ones *T. fibratum.* Those of the Maysville are perhaps intermediate. A number of specimens labeled as coming from the upper Cincinnatian from Belk Island are of the coarse type, *T. fibratum,* measuring 1½-plus in 2 mm.

PHYLUM ECHINODERMATA

CLASS CRINOIDEA FAMILY HETEROCRINIDAE

GENUS HETEROCRINUS. HALL

Crown subcylindrical, calyx small. Three radials transversely and more or less equally bisected, or compound, these being, in addition to the right posterior the right and left, anterior or sometimes the anterior in place of the latter. Anal tube delicate and straight, first tube plate resting on the shoulders of both posterior radial, but not further entering the cup. Arms irregularly dichotomous, somewhat divergent. Stem pentagonal, quinquepartite, with interradial sutures.

HETEROCRINUS HETERODACTYLUS. HALL

Calyx small, about 4 mm. in length and almost as wide. Arms about 15 mm. long. Basals pentagonal forming nearly one-third the height of the body. The species is characterized by the small size of the calyx compared with the column, which has a diameter almost half that of the calyx, and the irregularity in the arrangement of the plates of the arms.

EDEN

GENUS ECTENOCRINUS. S. A. MILLER

Calyx about as in Heterocrinus. Arms heteronomous, with ten main branches, straight, rather closely abutting, composed of a continuous series of syzygies of two plates each, the epizygals giving off ramules. Stem round tripartite (Zittel 1918, p. 212).

ECTENOCRINUS SIMPLEX. (HALL)

Pl. IX, fig. 21

Calyx small, a little longer than wide, tapering regularly from above to the column. Arms above their origin on the

second or third costal simple and composed of a single series of plates. Calyx and arms together give a subcylindrical form often overlooked because of their resemblance to a group of small stems. Length about 5 mm.

Eden and lower Maysville.

ECTENOCRINUS GRANDIS. (MEEK)
Pl. IX, fig. 22

A more robust species with the armplates proportionately shorter and more wedge shaped. Length of calyx about 8 mm. and the whole crown about 50 mm.

An associate of *E. simplex*. It is also listed from the Rogers Gap.

FAMILY MELOCRINIDAE

GENUS GLYPTOCRINUS. HALL

Calyx often highly ornamented, brachials passing imperceptibly into the arm plates and the IBr into the disk. Radials and costals subequal, distichals 2-8 or more. Arms rarely branching above the second bifurcation. IBr. numerous enclosing suplementary anals which sometimes form a series, also numerous interdistichals and interpalmers. Anus excentric at the top of a small protuberance. Disk depressed hemispheric extending very slightly above the level of the arm bases, composed of minute plates irregularly arranged, decreasing in size toward the arms. Arms 10-20. Pinnules slender, closely arranged. Column usually round.

GLYPTOCRINUS DECADACTYLUS. HALL

Calyx obconical, interradial and interdistichal spaces more or less flattened giving pentagonal or decagonal section. Surface ornamented by angular ridges, radiating from the center of each plate, those following the rays more prominent. Arms 20**,** simple. Costals and distichals two. Fairmount, Cincinnati region.

GLYPTOCRINUS DYERI. MEEK

Distinguished from *G. decadacylus* by the more globose calyx, and second bifurcation of the rays in the free arms. Eight distichals in the calyx, and one to seven additional ones before bifurcation. Ridges less angular. Arms thinner.

Corryville, Cincinnati region.

PHYLUM MOLLUSCOIDEA
CLASS BRACHIOPODA
FAMILY ORTHIDAE

GENUS DALMANELLA. HALL

Plano-convex or subequally biconvex Orthids, with pedicle valve the more convex, surface radially striated, and hinge line commonly shorter than greatest width of shell. Brachial valve with median groove. Teeth prominent, supporting lamellae produced forward circumscribing a rather short, suboval or sub-quadrate muscular area. Cardinal process prominent, continued as a median ridge separating the muscular impressions.

DALMANELLA EMACERATA. HALL

Pl. IX, figs. 15-18

D. emacerata is a semi-elliptical or subquadrate, finely striated, thin shelled species. Typically width about 20 mm., length about 0.75 width. Anteriorly 16-17 striae in 5 mm. Pedicle valve depressed convex, brachial flat, with faintly developed sinus.

Eden.

DALMANELLA BASSLERI. FOERSTE

Pl. II, figs. 1-3

A species of the *D. emacerata* type, distinguished (Foerste 1909, p. 215) by the somewhat more robust growth, the pedicle valve distinctly though not strongly convex, the brachial valve though nearly flat, sufficiently convex toward the beak to make the shallow sinus fairly distinct. Radiating striae coarser and their fasciculate arrangement more evident. In average specimens from the Jessamine there are 14-16 striae in 5 mm., width 15-20 mm., length, 0.75-0.80 width. In some of the more robust individuals the dorsal sinus is quite distinct.

Very common in the Hermitage and Jessamine formations of the Lexington limestone.

DALMANELIA MULTISECTA. (MEEK)

A relatively small, rounded, and more coarsely striated species than the above. Pedicle valve quite convex, rounded or centrally ridged, brachial valve flattened, and in the more robust forms with a well developed median sinus. Hinge line distinctly shorter than greatest width of shell. Commonly 10-12 striae in 5 mm. along the anterior margin. Width 12-15 mm., length 0.8-0.85 width.

This is the characteristic Eden *Dalmanella*, ranging up into the Mt. Hope and basal Fairmount.

DALMANELLA MEEKI. (MILLER)
Pl. **XV,** figs. 2, 3

This species is a larger and more robust form than *D. multisecta.* Muscular impressions deep set. Dorsal sinus well marked. Striae variable in coarseness, measuring as low as 6 or 7 in 5 mm. along the anterior margin to twice that many. Width typically about 18mm., length about 0.8 width.

Cumings lists this species (1908, faunal chart) from as low as the upper part of the McMillan. It is common in the Arnheim and Waynesville.

GENUS HEBERTELLA. HALL

Shell resupinate, the pedicle valve with well developed cardinal area. Surface radially striated. Fold and sinus well developed in most species. Teeth large, supported by thick lamellae which continue as strong ridges around a short, obcordate muscular area, which is divided by a median ridge. Diductors flabellate. Cardinal process elongate, simple. Shell impunctate except in the later species.

HEBERTELLA FRANKFORTENSIS. JAMES
Pl. III, figs. 1-3

A species characterized by the relatively short hinge line, with greatest width at, or a little anterior to the middle. Fold and sinus inconspicuous, visible only when viewed anteriorly. Plications usually simple, strong, 4-6 in 5 mm., anteriorly, about 40 in all, and more closely spaced laterally. Width commonly 15-20 mm., length 0.75-0.80 width, convexity about 0.5 width.

H. frankfortensis is first introduced low in the Jessamine, recurring again near the top and has its best development in the Benson. Where the typical Woodburn is developed it is not common. It recurs again in the Cornishville member of the Perryville.

HEBERTELLA OCCIDENTALIS. HALL
Pl. V, figs. 1, 2

Hinge line approximating the greatest width of the shell. Area common to both valves, extending much higher on the

pedicle. Brachial strongly and evenly convex with incurving beak. Sinus broad. Width 30-40 mm., length about 0.7 width. Common from the Fairmount through the Richmond.

HEBERTELLA SINUATA. HALL
Pl. XII, fig. 8

The characters distinguishing this species from *H. occidentalis* as listed by Hall (1847, p. 128) are:

1. The stronger and more prominent striae which are more regularly bifurcating; 2. beak of the pedicle valve more elevated and acute giving a greater height to the cardinal area; 3. brachial valve without the central depression (a faint sinus developed in the umbonal region) ; and 4. sinus more abrupt and deeper, often accompanied by a corresponding elevation in the brachial valve.

Different, combinations of these characters are common. Characters 2 and 3 are not of great practical value, and of the remaining two, coarsely striated, shallowly sinuate forms are as common as deeply sinuated ones. If the two are to be separated it would seem to be desirable to limit the species to the medium to coarsely striated forms with deep sinus, the latter character being suggested in the name.

It has essentially the same range as *H. occidentalis.*

HEBERTELLA SUBJUGATA. HALL
Pl. V, figs. 3, 4

A finely striated *H. occidentalis.* In the original description it occupies an end position in the series with the coarsely striated *H. sinuata* at the other end and H. *occidentalis* between. Mention was also made of the absence of the dorsal groove.

About the same range as the preceding species, but more common in the Maysville.

HEBERTELLA ALVEATA. FOERSTE

A *H. occidentalis* with a distinct and broad median depression extending from the beak to the anterior margin of the brachial valve. In the types the hinge line is prolonged giving acute cardinal angles. For the associated form with rounded cardinal angles and hinge line less than greatest width of shell

Foerste (1909, p. 224) has proposed the varietal designation *richmondensis.*

Liberty and Whitewater of Ohio and Indiana.

HEBERTELLA INSCULPTA. HALL
Pl. XV, figs. 4, 5

Shell small, subequally biconvex with greatest width at or a little anterior to the middle. Pedicle valve evenly convex, brachial marked by a prominent depression extending from the beak to the anterior margin. Surface marked by coarse bifurcating and trifurcating striae crossed by prominent lamellose lines of growth which are particularly conspicuous in the grooves between the striae and give the surface a sculptured appearance. Interior of pedicle valve with strong vascular markings. Width commonly 17-22 mm., length of hinge 0.75-0.80 width, length 0.80-0.85 width.

To this type of *Hebertella* Foerste (1914, p. 258) has applied the generic name of *Glyptorthis.*

H. insculpta occurs at several rather restricted horizons: a. base of the Blanchester division of the Waynesville; b. base of the Liberty (or top of the Waynesville); and, c. a zone 15'-20' above the base of the Liberty.

In Kentucky it is known from the base of the Liberty along the eastern area of out-crop as far south as Montgomery County.

Representatives of this genus corresponding in character to *H. occidentalis, H. sinuata,* and *H. subjugata* are common in the Cynthiana and basal Million. Two species have commonly been recognized. *H. maria parkensis* is a finely striated form with moderately developed sinus, essentially *H. subjugata. H. latasulcata,* (types from the Rogers Gap) has moderately coarse striae, and a broad shallow sinus, corresponding in character to *H. occidentalis.* The narrow muscle scar referred to by Foerste (1914, p. 131) in comparing *H. latasulcata* with *H. occidentalis* the writer does not believe to be characteristic of the Cynthiana species, and while the obcordate scar is better developed in the later forms, it is a feature of the larger in-

dividuals which are more common at the higher horizons. *H. maria parkensis* is also known from the Salvisa member of the Perryville.

GENUS PLATYSTROPHIA. KING

A spiriferoid Orthid with long straight hingeline and strongly plicated biconvex shell. Brachial valve with strong median fold, pedicle valve with corresponding sinus. Cardinal area about equally developed on each valve. Hinge teeth thick and prominent.

On the basis of the development of the plications of the fold and sinus Cumings (1903, p. 40) has grouped the species into the uniplicable, biplicate, and triplicate groups. All species described below are included in the *Triplicata* which has been further subdivided by McEwan (1919, p. 390) into—

A. Low fold subgroup
- P. colbiensis
- P. precursor
- P. clarksvillensis
- P. acutilirata

B. Ponderosa subgroup
- P. ponderosa
- P. ponderosa auburnensis
- P. preponderosa

C. High fold subgroup
- P. laticosta
- P. unicostata
- P. cypha

PLATYSTROPHIA COLBIENSIS. FOERSTE
Pl. IV, figs. 3, 4; Pl. VII, figs. 4-6

A small *Platystrophia* with only moderately elevated and not strongly compressed fold and shallow sinus. Plications 4 on the fold, 3 in the sinus, subequal in size. Lateral plications 8-10. Hinge line usually a little less than greatest width of shell. Width 21-22 mm., length about 0.8 width. The Woodburn specimens average somewhat smaller.

Common in the Woodburn and Cynthiana (Greendale) of Central Kentucky, also in the Rogers Gap.

PLATYSTROPHIA LATICOSTA (MEEK)
Pl. XI, figs. 1, 2

Shell transverse, with high, moderately compressed fold and deep sinus; cardinal angles seldom less than seventy degrees.

Lateral slopes flatly-convex with 5-7 broad, angular plications. Fold with four, sinus three plications, the lateral ones much reduced. Width commonly around 30 mm., length, 0.6-0.7 width.

Common throughout the Maysville, typically developed in the Fairmount. Similar specimens are found in the Waynesville.

PLATYSTROPHIA CYPHA. JAMES

Pl. XV, fig. 14

The characteristic features of *P. cypha* are the high compressed fold and deep sinus with a tendency toward the disappearance of the lateral plications leaving two prominent plications on the fold and one in the sinus. James' type is a form with extended hinge. Such forms have from 10-12 plications on the lateral slopes. On the other extreme are forms with more or less rectangular cardinal angles and 6-8 plications laterally. A contrast with *P. laticosta* is one of the degree of compression of the fold and reduction of the lateral plications. An extreme is a form with the general contour of *P. laticosta,* i. e. more or less rectangular cardinal angles and 5-6 plications on the lateral slopes, but with the lateral plications almost or entirely obsolete. For this "uniplicate *P. laticosta"* from the Bellevue, Cumings has given the name *P. unicostata.*

Foerste has recognized the variety *P. cypha conradi,* (Arnheim), a shell with the prolonged hinge, numerous plications on the lateral slopes, and stronger lateral plications on the fold and sinus.

McMillan—Richmond.

PLATYSTROPHIA CLARKSVILLENSIS. FOERSTE

Pl. XIV, figs. 4, 7

A species of the *P. laticosta* type but, with narrower and more numerous plications on the lateral slopes (7-9), the plications of the fold and sinus of more nearly equal size with the resulting relatively broader and less angular fold and sinus. The lateral slopes are somewhat fuller, giving less prominence to the fold.

Arnheim, Waynesville, and Liberty formations.

PLATYSTROPHIA ACULTILIRATA. CONRAD

Typical *P. acutilirata* is a strongly ventricose shell, characterized by a low, broad, rounded fold with four approximately equal plications, and numerous plications along the convex lateral slopes. There is every variation in hinge line from long, with spine-like cardinal extremities, to shorter than greatest width. The following varieties have been recognized:

var. *prolongata*—forms with spine-like cardinal extremities. The typical form of *P. acutilirata* has the very extended hinge and acute cardinal angles, but not spinelike; and var. *senex*—a gerontic form with greatly thickened shell, thickness often in excess of length and a tendency toward the more rectangular cardinal angle.

Liberty and Whitewater of Ohio and Indiana. The var. *prolongata* and var. *senex* are from the Whitewater.

PLATYSTROPHIA PONDEROSA. FOERSTE

Pl. XIV, fig. 15; Pl. XII, fig. 3

Characterized by the large size, greatly thickened valves, and quadrangular outline. Fold prominent, though rounded, with usually four plications. Plications on the lateral slopes 7-9.

Common from the Fairmount through the Arnheim, rare at higher levels.

PLATYSTROPHIA PONDEROSA VAR. AUBURNENSIS. FOERSTE

Pl. XIII, fig. 4

A variety with hinge line much shorter than greatest width of shell resulting in fewer plications on the lateral slopes (5 or 6) and a more globose form.

Very common in and characteristic of the Mount Auburn in the region around Cincinnati.

PLATYSTROPHIA PREPONDEROSA. MCEWAN

This species is based on specimens from the Catheys near Nashville, Tennessee. It is smaller than *P. ponderosa* and has a more compressed and elevated fold, these constituting the only differences. Greatest width 26-27 mm., width along hinge 24 mm., length 20 mm., thickness 20 mm.

Specimens of what may be this species were found at the top of a railroad cut about five miles southeast of Winchester on the Ruckersville road, just above the crinoidal limestone marking the introduction of abundant *Plectambonites rugosus*.

GENUS PLECTORTHIS, HALL

Resembles *Orthis* in the strong ribbing but differs in the comparatively low area of the pedicle valve and subequal biconvexity. Compared with *Hebertella* it lacks the fold and sinus and the shell is not resupinate.

PLECTORTHIS SORDIDA. HALL
Pl. XI, figs. 16, 17

A small rounded, subequally biconvex *Plectorthis* with hinge area inconspicuous and not exceeding one third the width of the shell. Width 8-9 mm. Length about the same. Surface marked with about twenty simple plications.

Fairmount, Cincinnati and vicinity.

PLECTORTHIS NEGLECTA. JAMES
Pl. XI, figs. 11, 12

A species in which the intercalation of the secondary plications begins within a few millimeters of the beak, others added anteriorly. These soon attain the strength of the primary plications giving a uniformly plicated shell. Width about 15 mm., length 0.65-0.80 width.

Characteristic of the Mt. Hope.

PLECTORTHIS PLICATELLA. HALL
Pl. XI, figs. 3, 4

A species with typically simple primary plications though in the larger individuals there is usually a trace of secondary plications anteriorly. Width of average individual around 20 mm., length about 0.7 width.

Fairmount of the Cincinnati region.

PLECTORTHIS FISSICOSTA. HALL
Pl. XI, fig. 5

Distinguished from *P. plicatella* by the addition of secondary plications at a distance of about 10 mm. from the beak. The primary plications remain more conspicuous to the anterior margin, where with the two or sometimes three secondaries a

fasciculate arrangement is distinct. The postero-lateral plications tend to remain simple.

Upper Fairmount around Cincinnati.

PLECTORTHIS AEQUIVALVIS. HALL

A shell distinguished from the preceding in that the secondary plications more nearly attain the strength of the primaries anteriorly.

These last three species characterize the Fairmount of southern Ohio and Indiana and adjoining parts of Kentucky.

FAMILY RHIPIDOMELLIDAE

GENUS DINORTHIS

A resupinate, impunctate shell with brachial valve convex, pedicle elevated at the umbo and becoming flat or gently concave anteriorly and laterally. Dental lamellae prominent, extended around the subquadrate muscular area. Cardinal process erect.

DINORTHIS PECTINELLA

Pl. I, figs. 7, 8

Shell subcircular to semi-elliptical, characterized by from twenty to thirty coarse, broadly rounded and widely spaced plications, suggestive of the Pelecypod genus *Pecten*. Width normally about 25-30 mm., length 0.8-0.9 width.

Characteristic of the Curdsville.

DINORTHIS ULRICHI. FOERSTE

Pl. III, figs. 4, 5

Of the *D. subquadrata* type differing in the following minor points (Foerste, A. F., 1909c, p. 320); 1. more conspicuous flattening of the pedicle valve; 2. a shallow sinus anterior on the pedicle valve of some specimens; 3. shell frequently wider posteriorly than across middle; 4. plications usually somewhat coarser; and, 5. muscular area of pedicle valve relatively smaller, occasionally less than half the length of the valve.

Characteristic of the upper Benson, recurring again in the Cornishville member of the Perryville.

DINORTHIS CARLEYI. (HALL)

Pl. XV, figs. 16, 17

Shell suboval to subquadrate, width 30-40 mm., length about 0.8 width. Characterized by the relatively large cardinal area

of the pedicle valve which is strongly recurved anteriorly bringing the beak some distance anterior to the hinge line. Radiating striations rather coarse and rounded. Beak of the brachia] valve strongly incurved.

Characteristic of the Oregonia member of the Arnheim as far south as Nelson County on the west, and Mason and Lewis counties on the east.

DINORTHIS SUBQUADRATA. HALL

Pl. XV, fig. 15

A subquadrate form with hingeline a little less than greatest width of shell and sharply rounded cardinal angles. Brachial valve evenly convex with a shallow sinus which sometimes extends up on the umbo. Pedicle valve a little convex at the umbo, becoming flat or slightly concave anteriorly and laterally, with beak smaller and less incurved. Lateral striae curving strongly outward, some terminating on the cardinal margin.

Common in Liberty and Whitewater faunas. It is ordinarily introduced just above the upper *Hebertella insculpta* horizon.

GENUS HETERORTHIS

HETERORTHIS CLYTIE. HALL

Pl. II, figs. 7, 8

A depressed plano-convex, transversely elliptical shell, with the general appearance of a *Strophomenid* but with open delthyrium. Surface striae fine. Pedicle valve convex, with large muscular impression extending anterior to the middle consisting of small adductors centrally situated and two greatly enlongate, flabellate diductors which do not unite in front. Cardinal process simple, prominent extended anteriorly as a median ridge through the muscular area. Shell substance punctate.

This genus is represented by a single species *H. clytie* Hall, from the lower Hermitage. Width about 30 mm., length 0.7-0.75 width.

FAMILY STROPHOMENIDAE

GENUS STROPHOMENA. Blainville

Resupinate concavo-convex shells, essentially biconvex in the sinuate species. The species described below may be conveniently grouped as follows:

A. Sinuate biconvex forms. Sinus on pedicle valve, fold on brachial. *S. millionensis, S. sinuata, S. sulcata;* B. muscular area of pedicle valve bordered by a distinct ridge, which is deflected anteriorly leaving a median gap. *S. planumbona, S. vicina, S. nutans, S. planoconvexa, S. maysvillensis,* and *S. vetusta;* C. flabellate muscular area. *S. incurvata.* and *S. neglecta;* and, D. muscle scar weakly delimited. *S. hallie.*

STROPHOMENA INCURVATA. SHEPARD
Pl. I, fig. 9

A rather large, semicircular, finely striated species. Cardinal angles 75-85 degrees. Muscular area of pedicle valve flabellate, with sharply raised border, deflected anteriorly leaving a gap. Radial markings extended beyond border. Interior of pedicle valve distinctly thickened along anterior and lateral margins. Length commonly 40-45 mm., width: length 4:3. Convexity of brachial valve 7-10 mm., in specimens 40 mm. wide.

Fenton (1928 Midland Naturalist Vol. XI, p. 147) abandons this species on the basis of Shepard's inadequate description and figures, and absence of the types.

Tyrone and Camp Nelson. Ulrich (1888, p. 108) also lists it from the Curdsville.

STROPHOMENA VICINA. FOERSTE
Pl. II, figs. 9, 10

A semi-elliptical, finely striated shell of the *S. planumbona* type. Width 30-35 mm., length 0.6-0.7 width. Convexity of the brachial valve 4 or 5 mm. in the semi-elliptical and 6-7 mm. in the more quadrate forms.

Characteristic of two horizons in the Lexington limestone, the upper Benson and Cornishville. This type of shell is next known in the upper Arnheim where it re-appears as *S. concordensis.* (Foerste 1912, pp. 36, 37).

STROPHOMENA MILLIONENSIS. FOERSTE

A small sinuate form distinguished from *S. sulcata* by the wider spaces between the radiating striae and relatively narrower shell. The striae are rather coarse, 4-6 in 2 mm. The largest specimen seen (Foerste) is 19 x 13.5 mm. Cardinal angles 80-90 degrees.

Base of the Eden from the vicinity of Million, Madison County Kentucky.

STROPHOMENA HALLIE. MILLER
Pl. VIII, figs. 11, 12

Small, subtriangular or subpentagonal, cardinal angles more or less rectangular. Brachial valve flattened posteriorly for 5-7 mm. then curving rapidly antero-laterally. Pedicle valve with a reversal of curvature near the middle resulting in a piano-, rather than concavo-convex shell. Striae moderately coarse, 4-5 in 2 mm. anteriorly. Width of larger individuals 27 mm., length, 0.85 width. Muscle scar of pedicle valve weakly delimited especially anteriorly.

In the Cincinnati area it is most common in the Southgate, though also present in the Economy. In Central Kentucky it ranges from just above the Rogers Gap beds to the base of the Garrard.

STROPHOMENA MAYSVILLENSIS. FOERSTE
Pl. XI, figs. 8, 9

Closely related to *S. planoconvexa*. It is larger and proportionately longer, triangular or pentagonal in outline due to the downward deflection of the antero-lateral parts of the brachial valve. Convexity of the brachial valve distinctly greater in the longer forms. Width, 25-35 or 40 mm., length, 0.9 width. Convexity frequently 0.4 length. Cardinal angles more or less rectangular rounded in the older individuals.

S. maysvillensis is introduced in the Mt. Hope in Central Kentucky, has its best development, associated with *Constellaria florida*, in the basal Fairmount, and occasionally ranges as high as the Orthorhynchula horizon of the upper Fairmount. In north central Kentucky and adjoining parts of Indiana and Ohio there are two *Strophomena* horizons in the Maysville, a lower one in the basal Mt. Hope where *S. maysvillensis* is common, and a higher one characterized by *S. planoconvexa* in the basal Fairmount. *S. hallie* is regarded as a precursor.

STROPHOMENA PLANOCONVEXA. HALL
Pl. XI, figs. 6, 7

Shell semi-elliptical, brachial valve moderately convex, pedicle valve but slightly concave giving a plano-convex

shell. Striae coarse, 3-4 in *2* mm. near the anterior margin. Width 25-40 mm., length, 0.7 width. Convexity of brachial valve commonly not more than 6 mm., concavity of pedicle valve 1-2 mm. Foerste has suggested that the difference in form between *S. maysvillensis* and *S. planoconvexa* is one of environment. *S. maysvillensis* being merely the more healthy form.

Throughout Northern Kentucky and adjoining parts of Ohio and Indiana *S. planoconvexa* characterizes a zone in the basal Fairmount. Farther south it occurs higher and ranges to the top of the Fairmount.

STROPHOMENA SINUATA. MEEK
Pl. XI, fig. 10

A sinuate *Strophomena* distinguished from *S. sulcata* by its somewhat larger size and coarser striae. The deeper, narrower sinuses are more common in *S. sulcata* than in *S. sinuata.* Width often 25mm., length, 0.6-0.65 width. Striae about 2.5 in 2 mm.

Fairmount of southern Ohio and Indiana, and northern Kentucky.

STROPHOMENA PLANUMBONA. HALL
Pl. XV, figs. 11-13

Shell finely striated, quadrate. Brachial valve flattened 2/3 of the way anteriorly from the hinge. Muscular area of pedicle valve circular, deeply impressed, bordered by curved, sharply elevated ridges which are deflected forward producing an anterior gap. Shell distinctly thickened along the anterior and lateral margins, crossed by vascular grooves. Striae normally subequal or alternating in size, less frequently an alternation of one coarse with 2 or 3 fine ones. Width, 30 mm., length, 0.75 width, striae 5 in 2 mm.

In the Richmond areas of southern Ohio *S. planumbona* is introduced near the base of the Clarksville, more commonly as the variety *elongata*, the typical forms common in the upper Blanchester and Liberty. Southward in Kentucky on both east, and west flank it is limited to the uppermost Waynesville and Liberty.

STROPHOMENA SULCATA. VERNEUIL
Pl. XV, figs. 9, 10

Shell biconvex with fold on the brachial and sinus on the pedicle valve, semi-circular, with hinge line about equal to greatest width of shell. Muscular area of the pedicle valve about three-tenths the width of the valve, bounded posteriorly and laterally by a sharply elevated border which disappears anteriorly. Width, 18-23 mm., length 0.8 width. Striae about three in 2 mm.

S. sulcata has a vertical range from the Clarksville to the top of the Whitewater. In the Liberty-Whitewater it is represented in Kentucky as far south as Madison and Marion counties. In the Waynesville it is known from the Clarksville in Lewis County.

STROPHOMENA NUTANS. MEEK
Pl. XV, figs. 7, 8

A strongly concavo-convex, finely striated species of the *S. planumbona* type with pentagonal outline. Margins of posterior half of shell only moderately divergent. Hinge occasionally a little extended. On the pedicle valve and anterior part of the brachial valve several fine striae alternate with a coarse one, posteriorly on the brachial valve the striae are coarser and subequal or alternating in size. Anterior and lateral margins of pedicle valve abruptly and strongly thickened on the interior, the thickened border crossed by strong vascular markings. Width, 20-30 mm., length 0.7-0.8 width. Foerste (1912, p. 70) regards the typical form as the retarded gerontic form of *S. concordensis.*

Associated with *S. neglecta* and *S. vetusta precursor* forming a conspicuous *Strophomena* zone with a vertical range of only a few feet in the middle Blanchester from Lewis County, Kentucky to southern Indiana.

STROPHOMENA NEGLECTA. JAMES

A large, subquadrate, finely striated species with flabellate muscle area in the pedicle valve. Width, 40-45 mm., length, 0.75 width. Hinge often extended. Shell thin, rather evenly concavo-convex. Muscle area of the pedicle valve large, circular to elliptical, diameter about 2/5 the width of the shell. Lateral border sharply elevated but impressed area rises gradually anteriorly.

Restricted to the middle Blanchester. Along the eastern area of out-crop it is known as far south as Bath County. It is known in southern Indiana but has not been listed from the western area in Kentucky.

STROPHOMENA VETUSTA. JAMES
Pl. XV, fig. 20

A large species often attaining a width of 40 mm., length, 0.7 width, with rectangular or slightly extended cardinal angles, and high cardinal area. Radiating striae very fine on the pedicle valve (18-21 in 5 mm.), much coarser (8-10 in 5 mm.) on the brachial valve. The presence on the pedicle valve of concentric wrinkles, growth lines, and the tendency of the striae to change their direction anteriorly and laterally gives a characteristic irregularity to the surface markings. Shell vertically wrinkled along the hinge line.

Middle Liberty to the top of the Whitewater (also Saluda). It is known in Kentucky as far south as Madison County in the east, and Nelson County in the west.

GENUS RAFINESQUINA. HALL AND CLARKE

Concavo-convex striated shell with straight hinge line and well developed cardinal area. Pedicle valve convex with faintly delimited flabellate diductors enclosing elongate adductors. Cardinal process bilobed.

RAFINESQUINA ALTERNATA. (EMMONS)
Pl. V, fig. 7

A common and variable species commonly around 40 mm. in width, length, 0.8 width. Cardinal angles rectangular to acute. Convexity variable. Striae alternating in size commonly one coarse to several fine ones.

Common throughout the Trenton-Richmond formations.

RAFINESQUINA ALTERNATA VAR. FRACTA
Pl. XIII, figs. 5, 6

A thin, fragile, flattened variety with length equalling or slightly exceeding width. Cardinal angles rectangular to slightly obtuse, lateral margins parallel or slightly convergent posteriorly. Width, 30-40 mm.

Common in the McMillan.

RAFINESQUINA WINCHESTERENSIS. FOERSTE

Pl. VIII, fig. 14, PL V, figs. 8, 9

Similar to *R. fracta* in general contour but thicker and more convex and the shell averages a little smaller. A characteristic Cynthiana species.

RAFINESQUINA ALTERNATA VAR. PONDEROSA. ULRICH

Pl. XIII, fig. 4

A large, massive variety with more deeply excavated muscle scars, and vascular markings and unusually large cardinal process. Width commonly 50-60 mm.

Common in the Bellevue at Cincinnati also in the upper Fairmount of the southern Bluegrass.

RAFINESQUINA NASUTA. (CONRAD)

Distinguished from *R. alternata* by the nasute anterior outline. Width commonly around 40-50 mm. Length somewhat greater.

McMillan beds of the Cincinnati region.

GENUS LEPTAENA. DALMAN

Concavo-convex, finely striated Strophomenids characterized by a conspicuous concentric wrinkling of the shell which is abruptly deflected anteriorly. Outline transversely subquadrate or semi-elliptical, hinge line forming greatest width. Muscle area of pedicle valve subcircular, with flabellate diductors. Cardinal process bifid. Interior of brachial valve prominently elevated at line of geniculation.

LEPTAENA RICHMONDENSIS. FOERSTE

Pl. XIV, figs. 1-3

Shell transversely subquadrate with more or less extended cardinal extremities. Width, 25-40 mm. Length, 0.5 width. This species differs from the well known *L. rhomboidalis* with which it was formerly identified by the shallower and less numerous wrinkles and broader striations with narrower intervening grooves. The shell is relatively wider and in most specimens the top of the pedicle valve is relatively flat.

A common and characteristic Richmond species appearing in the Oregonia member of the Arnheim as the variety precursor which is distinguished by the less conspicuous wrinkling, smaller

geniculation anteriorly and more convex pedicle valve. In Jefferson County Butts finds it in the *Rhynchotrema dentata* and *Constellaria polystomella* zones of the Arnheim.

PLECTAMBONITES. PANDER

Small, concavo-convex, very finely striated, transversely semi-elliptical Strophomenids. Hingeline forming greatest width of shell, cardinal extremities often acuminate. Cardinal process large, simple, occupying the partly closed delthyrium. Crural plates short giving rise to two septa.

PLECTAMBONIESS PLICATELLUS. ULRICH

Pl. VIII, figs. 15, 16

A very small semi-circular, remarkably coarsely striated (plicated) species. Width about 5 mm., length, 0.5 width. Five striae occur in a space of 5 mm. The plicated appearance is characteristic.

A characteristic species of the Fulton in the Cincinnati region.

PLECTAMBONITES RUGOSUS. MEEK

Pl. VIII, fig. 1; Pl. XVI, figs. 3, 4

A transversely, semi-circular, very finely striated shell. Width commonly 15-20 mm., length 0.5 width. Cardinal angles usually a little acuminate. A silky luster is a characteristic feature of the shell.

A very common species of the Eden. In Central Kentucky the introduction of this species in great numbers is regarded as marking the base of the Million. It is quite common at a horizon near the top of the Jessamine and again lower in the same formation. A somewhat larger form is characteristic of the Curdsville. It recurs again in the Richmond in the lower parts of the Clarksville and Blanchester divisions of the Waynesville, lower Liberty where it is very common, and again in the lower Whitewater.

FAMILY RHYNCHONELLIDAE SCHUCHERT

GENUS RHYNCHOTREMA. HALL

Rostrate, thick shelled, strongly plicate shells, with well marked fold on the brachial, and sinus on the pedicle valve. Deltidial plates concave, thick. Teeth strong. Median septum of brachial valve extending more than one half the length

of the shell, with the small cardinal process on its posterior extremity. Muscular impressions usually well defined. Beak of pedicle valve closely incurved over that of the brachial valve.

RHYNCHOTREMA INCREBESCENS. (HALL)
Pl. III, figs. 6-8

A small species with three plications in the sinus, four on the fold and 4-5 on either side. Length usually 10-15 mm., length :width = 1:1. It differs from *R. capax* chiefly in the small size, and more angular plications, fold, and sinus.

A characteristic species of the Lexington limestone with its best development in the Benson and higher formations, quite common also at various levels in the Jessamine. A small, more triangular form, *H. trigonale* is found in the Curdsville.

RHYNCHOTREMA CAPAX. (CONRAD)
Pl. XVI, figs. 5-7

A species varying from rather thin, flattened forms in the younger individuals to highly ventricose forms with thickness often exceeding length. Beaks closely incurved. Plications 4 on the fold and 3 in the sinus. Growth lines prominent. In the younger individuals where the size is comparable to that of the average *R. increbescens* the thickness is proportionately much less and fold and sinus are shallow.

A characteristic Richmond species ranging from the base of the Liberty to the Whitewater.

RHYNCHOTREMA DENTATUM. (HALL)
Pl. XIV, figs. 9-10

A subtriangular species characterized by the development of two plications on the fold and one in the sinus. Width 12-15 mm., length, 0.9 width. Lateral plications 3-4.

A characteristic species of the Whitewater of Ohio and Indiana, occasionally found also in the Liberty. A variety *R. dentatum arnheimensis* Foerste is a characteristic member of the Oregonia fauna throughout its extent, also of the middle Arnheim (*R. dentatum* zone) as defined by Butts (1915, p. 42) in Jefferson County, Kentucky. According to Foerste (1909a, p. 228) it is distinguished by its usually larger size, more triangular and less globose outline, especially posteriorly, and

the more angular plications. The majority of specimens seen by the writer from this horizon are relatively small.

GENUS ORTHORHYNCHULA. HALL AND CLARKE

A plicate *Rhynchonelloid* with the cardinal area extending about one third the width of the shell, shared by both halves, that of the pedicle valve being the higher.

ORTHORHYNCHULA LINNEYI. (JAMES)

Pl. IV, fig. 11; Pl. XI, fig. 13

The only described species is a subelliptical shell with the greatest width anterior to the middle. Pedicle valve with sinus, brachial with prominent fold. Four plications usually on the fold, three in the sinus, and about eight on either side. Width, 22 mm., length 0.9 width.

O. linneyi is found at three horizons in the local Ordovician, the Salvisa member of the Perryville, the Greendale member of the Cynthiana, and the upper Fairmount. Comparing specimens from these levels Foerste (1912, p. 133) states that the beaks of the Perryville forms are less incurved, that there is a tendency for the Fairmount forms to be more globose than those from the Cynthiana, and that there is a tendency among the Cynthiana individuals to increase the usual four plications on the fold to five or six.

FAMILY ATRYPIDAE GENUS ZYGOSPIRA. HALL

A small, rostrate, sub-circular, biconvex, plicated, genus. Pedicle valve with median fold, brachial with sinus. Spirals with few coils, apex directed inward. Primary lamellae united by transverse jugum.

ZYGOSPIRA RECURVIROSTRIS. (HALL)

Distinguished from Z. *modesta* (Foerste 1914, p. 132) by the broader and shallower sinus within which the plications are subequal while in that species the central plication is distinctly larger than those on either side. A corresponding difference in the pedicle valve is the slightly more evident fold in Z. *modesta* and the median groove along it a little more evident.

Very common throughout the High Bridge, Lexington and Cynthiana formations.

ZYGOSPIRA MODESTA. HALL
Pl. V, figs. 14-16

A small species. Width, 9 mm., length, 8 mm., thickness 4 mm., with low median fold on the pedicle valve and sinus on the brachial. The sinus is occupied by about four plications and 7-9 occur on each lateral slope. The median groove on the fold of the pedicle valve is distinctly wider than the adjoining grooves and in the sinus the corresponding plication is comparatively stronger.

Common from the Cynthiana to the Richmond.

ZYGOSPIRA CINCINNATIENSIS. MEEK

A comparatively large species with length, 8 or 9 to 14 mm., width, 1.2 length. It is distinguished from *Z. modesta* in addition to the larger size by the smaller number, hence coarser primary lateral plications (5-6 on each side), more common bifurcation of the lateral plications of fold and sinus and more prominent fold and sinus.

Fairview formation of southern Ohio, Indiana, etc.

ZYGOSPIRA KENTUCKIENSIS. JAMES
Pl. XIV, figs. 11, 12

A large species attaining a length of 14-15 mm., distinguished from *Z. cincinnatiensis* by the greater number and smaller size of the plications.

Characteristic of the Waynesville of Oldham, Jefferson, etc., counties, also Clark and adjoining counties in the eastern area of outcrop.

CLASS BRYOZOA

FAMILY CERAMOPORIDAE

GENUS CHILOPORELLA. ULRICH

Zoarium forming parasitic sheets giving rise to flabellate fronds. Apertures ovate with prominent lunaria. Mesopores numerous.

CHILOPORELLA FLABELLATA. ULRICH
Pl. XII, figs. 1, 2

This is the only described species. It forms flabellate expansions from a few to 15 mm or more thick. Rounded monticules sometimes developed. Mesopores more or less isolating

the zooecia. Apertures round to oval, constricted posteriorly where a conspicuous hood shaped lunarium is developed. A characteristic and common form in the Corryville.

GENUS COELOCLEMA. ULRICH

Ramose hollow zoaria with oblique zooecial apertures. Lunaria hood-like. Mesopores abundant.

COELOCLEMA COMMUNE. (ULRICH)

Distinguished from *C. alternatum* by the more robust growth, well marked maculae with subsolid centers (closed mesopores) surrounded by apertures somewhat larger than normal.

Abundant in the Eden, most common in the Economy.

COELOCLEMA ALTERNATUM (JAMES)

Zoarium of somewhat irregular, hollow or compressed branches, 2-5 mm. in diameter. Maculae absent. Zooecial aperatures in more or less regular diagonal series, about six in two millimeters.

A common species of the middle and upper Eden.

COELOCLEMA OWENI. (JAMES)

Zoarium of small hollow contorted stems with prominent lunaria, giving the surface a rough appearance. In tangential section the lunarium is semicircular with its ends indenting the zooecial apertures.

A characteristic species of the Mt. Auburn of the Cincinnati region.

FAMILY *MONTICULIPORIDAE*

GENUS MONTICULIPORA. D'ORBIGNY

Cystiphragms are developed in both (m)[1] and (im). Particularly characteristic are the granulose wall structure and the small, usually numerous acanthopores, which lack the central lumen and concentric structure. Mesopores variable.

MONTICULIPORA MAMMULATA. D'ORBIGNY

Pl. X, fig. 7

Zoarium massive to lobate, surface with conical or somewhat elongate monticules composed of zooecia slightly larger than normal. Mesopores few. Acanthopores small, numerous. Longitudinal section shows a succession of (m) and (im), the

[1]Thruout the paper the mature and immature regions are indicated by (m) and (im).

former characterized by the thickening of the walls and closer spacing of diaphragms.

Fairly common in the Fairmount of the southern Bluegrass.

MONTICULIPORA MOLESTA. ULRICH

Pl. XIII, fig. 9

A species distinguished from the preceding by its frondescent growth. It shows the same succession of (m) and (im). Characteristic of the Bellevue.

MONTICULIPORA EPIDERMATA. ULRICH AND BASSLER

Distinguished from *M. mammulata* by its mode of growth which is more discoidal with diameter up to 30 cm. and height about ½ diameter. Base concave with concentrically wrinkled epitheca. Mesopores more numerous. Acanthopores small, inconspicuous, appearing as small grannules, 2-3 to the zooecium. Characteristic of the Whitewater. The writer has collected a similar *Monticulipora* from the Oregonia of Clark County which differs in the larger and more numerous acanthopores.

GENUS HOMOTRYPA. ULRICH

Cystiphragms are restricted to the (m) and mesopores are few or wanting. Bassler (1903 pp. 566-568) has grouped the described species as follows:

A. diaphragms present in the (m)

B. diaphragms absent in the (m)

1—cystiphragms in all zooecia

2—cystiphragms present only in the maculae.

HOMOTRYPA CURVATA. ULRICH

Zoarium of smooth, compressed branches about one half cm. thick. Acanthopores small, 3-4 surrounding a zooecium. Mesopores absent except in the maculae. Diaphragms in both (m) and (im). Ten zooecia in two mm.

Common in, and characteristic of the Fairmount in the Cincinnati region.

HOMOTRYPA OBLIQUA. ULRICH

A tuberculated dendroid species with cylindrical or slightly compressed branches 5-15 mm. in diameter. It is distinguished from *H. curvata* by the absence of diaphragms and the slight crinkling of the zooecial walls in the (im).

Common in the Fairmount, Bellevue, and Corryville.

HOMOTRYPA CINCINNATIENSIS. BASSLER
Pl. X, figs. 2-4

Zoarium small, composed of cylindrical to subfrondescent branching stems 2-4 mm. in diameter. Surface smooth, zooecia direct, about nine in *2* mm. Mesopores moderately developed in maculae and elsewhere. Acanthopores small, variable in number, sometimes 8-10 around a zooecium.

Common in the Fairmount of the southern Bluegrass.

HOMOTRYPA PULCHRA. BASSLER

Zoarium of smooth surfaced, branching fronds 3-5 mm. in thickness. Maculae not elevated but conspicuous because of great size of the zooecia. Mesopores few and restricted to the maculae. Zooecia thin-walled, direct. Acanthopores absent. Diaphragms 1-1½ tube diameters apart in the (im), 4-5 times as numerous in the (m), associated with an increasingly crowded series of cystiphragms.

Characteristic of the Mount Auburn in the Cincinnati region.

HOMOTRYPA BASSLERI. NICKLES
Pl. XIV, fig. 19

Zoarium of small cylindrical or flattened branches 4-5 mm. thick, with strongly tuberculed surface. Zooecia small, 10 in 2 mm. Acanthopores small, moderate in number. Diaphragms absent.

Common in the upper Arnheim *(Constellaria polystomella* zone) along the western side of the arch.

HOMOTRYPA WORTHENI. (JAMES)
Pl. XIV, fig. 18

A strongly and sharply monticuled ramose species distinguished from *H. bassleri* by the more numerous acanthopores, presence of a moderate number of diaphragms in the (m) and in tangential section by the thick walled zooecial tubes with characteristic dotted or granular structure.

Characteristic of the Whitewater. The figured specimen is from the Oregonia from west of Lebanon in Marion County where it occurs in abundance. The writer cannot separate it from *H. wortheni.*

HOMOTRYPA SP.

A species of *Homotrypa* is common in the light colored clay at the top of the Oregonia in Lincoln County, a ramose, slightly tuberculated form having the general appearance of *H. richmondensis* or *H. cylindrica,* and agreeing with the latter in many points of internal structure. The walls are much thickened in the (m) and the acanthopores are large and numerous occupying about one-third of the junction angles. In longitudinal section it differs in that the cystiphragms are limited to the early part of the (m), only occasionally occurring higher. In the (im) occasional diaphragms are developed and are present also associated with the cystiphragms in the (m) and continuing above them.

HOMOTRYPA NORWOODI. (NICKLES)

Pl. V, fig. 12

As originally described this species, referred to *Homotrypella,* forms rounded or compressed branches, 3-6 mm. thick and 2-12 mm. wide. Surface covered with small, conical monticules. Apertures polygonal, walls of only moderate thickness, and averaging 12 in 2 mm. Mesopores absent except in the monticules which are composed of zooecia slightly larger than the average. Acanthopores small, very numerous, three to five surrounding, and commonly indenting the apertures. Diaphragms widely spaced in the (im). Cystiphragms small, numerous in the (m), accompanied by an equal number of diaphragms. The types are from Pleasant Valley, Carlisle County.

Numerous specimens of a very similar form have been collected by the writer from exposures of the upper Cynthiana east of Winchester and other localities which differ from the species as described above in the more robust growth, attaining a thickness of 8 mm., and in the absence of acanthopores. The zooecia are a little smaller averaging about 10 in 2 mm. In spite of the difference in development of acanthopores the writer regards the two as specifically the same. In both the original specimens and in those just mentioned the meagre development of mesopores does not suggest the genus *Homotrypella*.

A common and characteristic fossil of the upper Cynthiana.

GENUS HOMOTRYPELLA. ULRICH

Distinguished from *Homotrypa* by the development of numerous mesopores.

HOMOTRYPELLA HOSPITALIS. (NICHOLSON)

This species is exceptional for the genus in its massive, hemispherical form, commonly attached to brachiopod or other shells, and 2-4 cm. in diameter. Surface smooth or with maculae of larger apertures slightly elevated. Mesopores numerous, closely tabulated. Acanthopores numerous and strong. Cystiphragms line the zooecial tubes. In assigning this species to *Homotrypella* instead of *Prasopora,* only a very short region in the proximal end which is free of cystiphragms may be recognized as the (im). The difference in development of acanthopores is distinct.

Blanchester, Liberty and Whitewater.

GENUS ASPIDOPORA. ULRICH

Zoarium discoidal, composed of two or more superimposed layers, lower size concave, with wrinkled epitheca. Acanthopores small. Diaphragms usually wanting in the zooecia, close set in the mesopores.

ASPIDOPORA NEWBERRYI. (NICHOLSON)

Pl. IX, fig. 8

A thin discoidal expansion about 2 cm. in diameter. Surface smooth with maculae of larger apertures. Diaphragms closely spaced in the mesopores. Cystiphragms lining the walls of the zooecia.

A common and characteristic species of the Economy member of the Eden.

ASPIDOPORA ECCENTRICA, (JAMES)

Pl. IX, figs. 3-7

A small species about 5 mm. in diameter characterized by the eccentricity of the concentrically wrinkled epitheca.

Southgate member of the Eden.

GENUS PRASOPORA. NICHOLSON AND ETHERIDGE

Zoarium more or less hemispherical with concentrically wrinkled epitheca. Zooecia thin-walled and generally surrounded by angular mesopores. Acanthopores when present,

never numerous or strong. The massive Monticuliporas differ in the granular acanthopores and wall structure.

PRASOPORA SIMULATRIX. ULRICH
Pl. II, figs. 16, 17

Zoarium flattened discoidal to subconical, diameter normally 2-10 cm., base more or less concave. Zoarium occasionally lo-bate. Apertures subcircular, 7-8 in 2 mm., more or less in contact except at the junction angles. Maculae conspicuous, of larger apertures and more numerous mesopores. Acanthopores absent. Diaphragms closely spaced, about one-half tube diameter apart, accompanied by a series of cystiphragms lining the zooecial walls.

A common and characteristic form of the Hermitage and Jessamine, in the latter attaining the subconical form ("chocolate drop bryozoan"). Occasionally also in the Benson.

PRASOPORA SP.
Pl. VI, fig. 5

In the lower Cynthiana, particularly in the southern Bluegrass, occasionally also in the Brannon, there occurs a form differing from P. *simulatrix* in the discoidal form and presence of small acanthopores at many of the junction angles. In these respects it suggests the following species. Zoarium 4-8 cm. in diameter.

PRASOPORA FALESI. (JAMES)
Pl. II, figs. 11, 12

James based his species on specimens resembling small individuals of *P. simulatrix*, characterized by the presence of a conical, sharp pointed groove impressed on the wrinkled under surface. According to Bassler (1906, p. 48) this groove, representing the excavation left by the object (*Hyolithes* or tapering end of a cephalopod) upon which the colony grew, lacks systemmatic value. The species is distinguished by its smaller size (about 2 cm. in diameter), flatter form, weaker epitheca, and presence of small acanthopores.

Hermitage and Jessamine. In spite of the lack of systematic value of the basal groove the form it represents does have stratigraphic value.

GENUS PERONOPORA. NICHOLSON

A bifoliate Monticuliporid.

PERONOPORA VERA. NICKLES

Frond 2-6 mm. thick and 10 or more cm. high, more or less undulating and branching. Apertures circular, 7-8 in 2 mm. Mesopores numerous, occupying the relatively wide interspaces. Acanthopores small, numerous. Maculae conspicuous, of larger apertures, often with a central cluster of mesopores. Cystiphragms lining the zooecial tubes, accompanied by a smaller number of diaphragms.

Common in the Eden and Fairview.

PERONOPORA DECIPIENS. (ROMINGER)

Distinguished from *P. vera* by the fewer mesopores, correspondingly narrower interspaces, and smaller apertures. The zoarium in some specimens is almost massive.

Common through the Maysville and Richmond.

PERONOPORA MILLERI. NICKLES

A form closely related to *P. vera* and *P. decipiens.* According to Nickles the zooecia are smaller than in *P. vera.* Zoarium commonly 1-3 mm. thick. Eight zooecia occur in 2 mm. Acanthopores numerous, often inflecting the zooecial walls, from 2-5 surrounding each aperture. The writer is not certain that he can separate it from these later forms.

A very common fossil of the Cynthiana, occuring in great numbers in the lower part (Greendale), common also in the Brannon.

FAMILY HETEROTRYPIDAE

GENUS HETEROTRYPA[1]. NICHOLSON

Zoarium frondescent; acanthopores small. Mesopores generally abundant; diaphragms numerous.

HETEROTRYPA PARVULIPORA. ULRICH AND BASSLER

Pl. VII, fig. 2

A large frondescent species distinguished from *H. frondosa* by the smaller zooecia (10 in 2 mm.), smaller and generally fewer acanthopores, and fewer mesopores. Surface smooth, or with slightly raised maculae.

[1]Cumings (E. R. 1902, pp. 197-217) has questioned the distinctness of the three genera Heterotrypa, Dekayella and Dekayia.

Common in the Greendale and Millersburg phases of the Cynthiana.

HETEROTRYPA FRONDOSA. O'ORBIGNY

Zoarium large, frondescent, surface with small, sharp monticules at 3 mm. intervals. Zooecia moderately thick-walled, polygonal to circular. Mesopores abundant, rather uniformly distributed. Zooecial walls much thickened in the deep (m). Diaphragms absent in the (im), moderately to very abundant in the (m). Acanthopores fairly numerous, of small size with occasionally a larger one.

McMillan formation of Cincinnati and vicinity.

DEKAYELLA

Ramose or frondescent bryozoa distinguished from *Heterotrypa* by the development of two sets of acanthopores, large and small.

DEKAYELLA ULRICHI

Pl. IX, fig. 23

Zoarium ramose to subfrondescent, 5-10 mm. in diameter. Surface smooth to sharply monticulated, maculae of larger zooecia and mesopores. Zooecia rounded, 7-8 in 2 mm. Mesopores abundant. Acanthopores fairly numerous, of two sizes. Diaphragms few to absent in the axial region, ½-2 diameters, apart in the periphery, closely set in the mesopores.

A characteristic fossil of the McMicken member of the Eden, ranging from the Southgate to the Fairmount.

DEKAYELLA TRENTONENSIS. (ULRICH)

Zoarium dendroid, branches compressed, dividing frequently and rather irregularly, from 4-10 mm. in width. Surface smooth, or with low, rounded monticules 2.5 mm. apart; occupied by clusters of cells a little larger than the average, with occasionally a few mesopores at their summits. Apertures sub-angular, about, 9 in 2 mm. Interspaces rather thick. Acanthopores large and prominent, when preserved, about 6 or 7 in 3 mm. Zooecia with thin slightly flexuous walls in the axial region and with diaphragms 2-4 times their diameter apart. As they curve gently into the (m), the walls thicken, and diaphragms become much more numerous. (Nickles 1905, p. 42)

According to Nickles, from the Lexington series associated with *M. multitabulata* and P. *simulatrix.* This indicates the Jessamine.

DEKAYELL A FOLIACEA. ULRICH AND BASSLER

A flabellate *Dekayella* from 5-10 mm. thick. Zooecia angular, about 8 in 2 mm. Mesopores few, somewhat variable. Diaphragms remote in the axial region, 1½-3 to the tube diameter in the periphery. Large acanthopores about 2/5 as numerous as the zooecia, small set several times as numerous, sometimes obsolete in the older specimens.

Described as from the Lexington limestone, later referred to the Cynthiana (Bassler 1915), Lexington, Kentucky.

DEKAYELLA MILLERI. SP. Nov.

Pl. VI, figs. 6, 9

The type consists of the basal part of a ramose or subfrondescent zoarium 2 cm. thick, branching, and with a rounded celluliferous base. Surface with low monticules consisting of zooecia larger than normal. Zooecia thin-walled, sometimes crinkled, in the (im), turning fairly abruptly into the (m) which is 2-3 mm. thick. Diaphragms few to absent in the (im) but occasionally a cluster of diaphragms 1-3 diameter apart occurs, in the (m) 1/3-1/2 diameter apart. The inverted *V* structure and hollow central tube of the acanthopores distinct. In tangential section the zooecia are relatively thin-walled, polygonal, 10 in 2 mm. Mesopores practically restricted to the maculae. Acanthopores of two sizes, the larger about 2/3 as numerous as the zooecia, frequently 2/5 the size of the zooecial tubes. The smaller ones are much more numerous, but in the greater part of the sections could not be detected.

The species is characterized by the rounded base of the zoarium and its large size. Other features are much like those of *D. foliacea*. The acanthopores are more numerous and the zooecia smaller. Surface features are essentially as in *Heterotrypa parvulipora*.

Greendale member of the Cynthiana from the vicinity of Lexington.

GENUS DEKAYIA. M. E. AND H.

Distinguished from *Heterotrypa* in the single set of large acanthopores, and more meagre development of diaphragms in the periphery.

DEKAYIA ASPERA. M. E. AND H.
Pl. XI, fig. 15

Zoarium ramose 6-10 mm. in diameter, characterized by the very large acanthopores, conspicuous externally as small spines. Surface more or less smooth, with maculae of larger cells and mesopores. Mesopores lacking except, in the maculae. Zooecia polygonal, 10 in 2 mm. Diaphragms absent in the (im), and few to absent in the (m).

The species ranges from the McMicken to the Fairmount, and is especially characteristic of the latter horizon.

GENUS CYPHOTRYPA. ULRICH AND BASSLER

Massive Heterotrypids with thin-walled, prismatic zooecia. Diaphragms and acanthopores well developed. Mesopores wanting.

CYPHOTRYPA FRANKFORTENSIS. ULRICH AND BASSLER
Pl. IV, fig. 13

Zoarium of thick undulating to subspherical masses. Zooecia thin-walled 9-10 in 2 mm., with comparatively large acanthopores averaging about one to the zooecium. Surface usually with small sharp monticules. Diaphragms wanting in the (im), one to two diameters apart in the (m). It is characterized by the monticuled surface, small zooecia, few acanthopores and absence of diaphragms in the (im).

Common in the upper Benson, also in the Cornishville and Cynthiana formations of Central Kentucky.

CYPHOTRYPA CLARKSVILLENSIS. ULRICH
Pl. XIV, fig. 14; Pl. XV, fig. 6

Subspherical to massive zoaria. Surface smooth or with maculae of larger zooecia slightly elevated. Zooecia 9-10 in 2 mm. Acanthopores large, occupying almost all junction angles. Diaphragms widely spaced in the (im), one to two diameters apart in the (m). The (m) recurs at successive levels in the zooecial tubes.

Common in the Waynesville, especially the lower part along the western side of the arch, also along the eastern from Montgomery County north. Common also in the Oregonia member of the Arnheim of the southern Bluegrass.

GENUS STIGMATELLA. ULRICH AND BASSLER

Zoarium variable. Characterized by the periodic thickening of the walls of the zooecial tubes, the development of acanthopores in these zones, and the meagre development of diaphragms.

STIGMATELLA DYCHEI. (JAMES)

Pl. XV, fig. 1

Zoarium an expansion loosely incrusting crinoid stems, in size up to 60 mm. in diameter. It is characterized by its zoarial habit, the practical absence of mesopores, thin-walled prismatic zooecia, acanthopores of fair size in the periodic zones but small or absent elsewhere, and the almost complete absence of diaphragms.

Characteristic of the Mount Auburn in the Cincinnati region. It is not common.

FAMILY CONSTELLARIDAE

GENUS CONSTELLARIA. DANA

Dendroid or frondescent zoaria with depressed stellate maculae, the interray spaces occupied by raised clusters of zooecia. Mesopores chiefly in the maculae, with gradually crowding diaphragms.

CONSTELLARIA TERES. ULRICH AND BASSLER

Pl. IV, fig. 12

Characterized by its mode of growth, consisting of rigid cylindrical to subcylindrical stems 5-10 mm. in diameter bifurcating at regular intervals, seldom less than 50 mm. Diaphragms are more abundant in the (m) than in *C. florida,* and in the (im) are 2-3 tube diameters apart.

Abundant in the Woodburn, also the Greendale member of the Cynthiana.

CONSTELLARIA FLORIDA. ULRICH

Pl. VI, fig. 1-2; Pl. X, fig. 1

Zoarium ramose or subfrondescent, 3-5 mm. thick, with conspicuous stellate maculae spaced at intervals of about 2½ mm.,

consisting chiefly of angular mesopores, commonly closed at the surface, and largest near the center of the cluster. In between the rays are groups of 5-15 zooecia compactly wedged together and forming conspicuously elevated radial ridges. These often coalesce to form more or less continuous transverse ridges. In shallow sections innumerable minute acanthopore-like structures are present in the zooecial walls and secondary material closing the mesopores. Diaphragms few in the zooecia, practically wanting in the (im). Mesopores closely tabulated, increasingly so as the surface is approached, the diaphragms occurring at the same level in adjoining tubes.

Common in and characteristic of the Fairview formation, also present in the Greendale division of the Cynthiana. A variety *C. florida prominens* Ulrich with monticules about twice the normal size occurs in the McMicken member of the Eden and the Fairview.

CONSTELLARIA EMACIATA. ULRICH AND BASSLER

Pl. VII, fig. 3

This species agrees with *C. florida* in all internal characters but differs in the dwarfed growth and the more sharply and more narrowly rayed maculae. "The usual growth obtaining in *C. florida is* of rather broad, flat branches, seldom less than 10 mm. in breadth and 3 or 4 mm. in thickness dividing rather regularly at intervals of several centimeters. *C. florida emaciata,* however, is dwarfed in growth, the branches being usually rounded and from 3 to 5 mm. in diameter but sometimes reaching a breadth of 6 or 7 mm. Division occurred at short, irregular intervals, and an entire zoarium consisted of a small clump of closely interwoven narrow branches instead of a rather broad expansion as in *C. florida"* (Ulrich and Bassler, 1904a, p. 38).

Common in the Cynthiana of Central Kentucky. A single specimen was found in the upper Benson. Many individuals of C. *florida* from the Fairview are similar.

CONSTELLARIA FISCHERI. ULRICH

Pl. VI, figs. 3, 4

Zoarium frondescent, sometimes of small flattened branches. Surface usually smooth but sometimes slightly monticulated.

It is distinguished from *C. florida* by the much smaller and more closely spaced maculae which are two or three times as numerous within a given area, commonly not elevated, and by the nature of the maculae. The zooecia in the interray spaces are not wedged together but are more or less separated by mesopores. When the zoarium is monticuled it is the maculae (mesopores) that are elevated.

Common in the Greendale division of the Cynthiana.

CONSTELLARIA LIMITARIS. ULRICH

A smooth surfaced, ramose or subramose species usually 5-10 or more mm. in diameter with stellate maculae essentially as in *C. florida* but, without the elevated clusters of zooecia in the interrays. Maculae on the same level with or slightly depressed below the general surface.

Common at various horizons in the Richmond from the Waynesville to the Whitewater. A similar form occurs in the Cynthiana.

CONSTELLARIA POLYSTOMELLA. NICHOLSON
Pl. XIV, fig. 17

A species resembling *C. florida,* distinguished by the more f'rondescent growth, the numerous diaphragms in the (im) (1-1½ tube diameters apart) and the nature of the "stars." According to Nicholson (1875, p. 215) "the different stars are definitely bounded . . . . .and appear to occupy definite polygonal areas, whilst in the former no line of demarcation can be detected between the different stars other than that afforded by the outer terminations of the elevated ridges. Each star is (in the best preserved portions of the coral) circumscribed and separated from adjacent stars by a distinct hexagonal border which has no great width and is occupied solely by the coenenchymal tubuli and not by the ordinary corallites." The writer has been unable to use this latter feature with the numerous specimens from the Arnheim and some from the Waynesville.

Common throughout the Richmond appearing first in the upper Arnheim.

FAMILY BATOSTOMELLIDAE

GENUS ERIDOTRYPA. ULRICH

Zoarium ramose, with more or less oblique, thick-walled zooecia. Diaphragms most numerous in the early portion of the short (m). Acanthopores small, few or wanting. Mesopores variable.

ERIDOTRYPA AEDILIS. (EICHWALD)

Pl. II, figs. 13, 15; Pl. VIII, fig. 13

This species, commonly known as *E. mutabilis* Ulrich consists of smooth, cylindrical, infrequently dividing branches. Zooecia more or less oblique with thick interspaces. In the younger specimens the apertures are drawn out anteriorly, in the older, the zooecia are more direct and the apertures sub-circular. Maculae present. Mesopores variable. Acanthopores represented by dark spots at the junction angles. The zooecial tubes curve gradually toward the surface. Diaphragms about 2 diameters apart in the (im) and about 1 D. apart in the (m).

Lexington limestone and Cynthiana.

ERIDOTRYPA BRIAREUS. (NICHOLSON)

Pl. V, fig. 5

The chief feature is in the nature of the zoarium which forms smooth cylindrical branching stems 3-10 mm. in diameter with a rounded or pointed base. Zooecia rather thick-walled, oblique, with oval apertures in the more slender zoaria, about 7 in 2 mm. Acanthopores absent. Mesopores few. Diaphragms particularly common in the early part of the (m).

Common in and characteristic of the Cynthiana. An earlier though not common occurrence, is in the Brannon.

GENUS BYTHOPORA. MILLER AND DYER

Zoarium of smooth slender branches, with small oblique zooecia, the apertures narrowing above and with channeled interspaces. Mesopores and diaphragms few or wanting. Acanthopores never numerous.

Cumings and Galloway (1913, p. 61) recognize two groups within the genus; *B. arctipora* group—characterized by delicate zoaria, rather large zooecia and scarcity of diaphragms and acanthopores; and, *B. gracilis* group—characterized by larger zoaria and conspicuous acanthopores.

BYTHOPORA ARCTIPORA. (NICHOLSON)
Pl. IX, fig. 1, 2

A slender ramose species, 1-2 mm. in diameter, with oblique apertures which are attenuated above. These are arranged in obscurely longitudinal alternating series. The borders are distinctly marked off by impressed lines.

Common in and characteristic of the Eden shale of Cincinnati and vicinity.

BYTHOPORA GRACILIS. (NICHOLSON)
Pl. XIII, fig. 1

Zoarium dendroid, of smooth cylindrical branches 2-3 mm. in diameter. Zooecia small, about ten in 2 mm., opening obliquely on the surface with circular or elliptical apertures between which occur a moderate number of minute more or less circular mesopores. Small acanthopores present. Walls very thick and completely amalgamated in the (m). A few diaphragms occur in the (m).

Common in the upper Fairview and McMillan.

BYTHOPORA MEEKI. (JAMES)
Pl. XV, fig. 19

Distinguished from *B. gracilis* in the more robust zoarium (6-10 mm.) and consequently less oblique apertures.

Common in the Richmond from the Waynesville up.

BYTHOPORA DELICATULA. (NICHOLSON)

A very slender form with characters essentially as in *B. gracilis* but of smaller size and lacking diaphragms and mesopores. Zooecia emerge very obliquely with oval apertures measuring about 8 in 2 mm. longitudinally.

Common in the Waynesville and higher formations of the Richmond.

FAMILY AMPLEXOPRIDAE

GENUS AMPLEXOPORA. ULRICH

Zoarium ramose, discoidal, or massive. Zooecia prismatic. Acanthopores variable. Diaphragms often quite irregular, oblique or curved.

AMPLEXOPORA SEPTOSA. ULRICH
Pl. XI, fig. 14

Zoarium ramose, 5-10 mm. in diameter. Maculae composed of larger zooecial apertures and some mesopores, sometimes a little elevated. Diaphragms few in the (im), about a half-tube

diameter apart in the (m). Zooecia polygonal with numerous small acanthopores inflecting[1] the zooecial walls.

Common in the McMicken and Fairview. Nickles recognized the Mt. Hope as the *A. septosa* zone.

AMPLEXOPORA FILIASA
(Not D'Orbigny according to Cumings, 1907, p. 765)

A massive species 25-100 mm. in diameter and 2/3-3/4 as high. Surface monticulated. Zooecia thin walled, polygonal, 9 in 2 mm. Acanthopores small, numerous. Longitudinal sections show alternating zones of (m) and (im), with diaphragms one to two diameters apart in the (im), and one half to one third diameters apart in the (m).

Fairmount, Bellevue, and Corryville around Cincinnati.

AMPLEXOPORA ROBUSTA. ULRICH
Pl. XIII, figs. 7-10

Zoarium dendroid, of smooth cylindrical stems 10-12 mm. in diameter. Maculae conspicuous at intervals of 3-4 mm. composed of larger apertures. Zooecia thin-walled, polygonal, 7-8 in 2 mm. Mesopores absent. Zooecia curving uniformly toward the surface, with diaphragms never numerous in the (im), and closely spaced in the (m). Here they frequently simulate cystiphragms. The nature of the tangential section varies with the age of the specimen and depth of the cut. In a shallow section of a robust individual the wall is typically amalgamate and about 2/5 the diameter of the aperture in thickness, has a well marked cingulum, and acanthopores are but feebly shown. A little deeper, or in younger individuals, the cingulum disappears, small acanthopores become conspicuous at the junction angles with a row of very small ill-defined ones in between, 2-4 to each side of the aperture, giving a granular appearance to the wall. With greater depth these minute acanthopores disappear and the sharp black line of the integrate wall becomes distinct. Diameter of the normal zooecium about 0.25 mm.

This species is listed from the Bellevue around Cincinnati. It is very common in the Mount Auburn, again in the Sunset of the southern Bluegrass.

GENUS RHOMBOTRYPA. ULRICH AND BASSLER

Ramose forms with the zooecial tubes rhombic or quadrate in cross-section in the (im). Acanthopores usually wanting.

RHOMBOTRYPA QUADRATA. (ROMINGER)

Pl. XVI, fig. 11

Zoarium ramose to lobate, diameter of branches 4-10 mm. Surface smooth or with maculae of larger apertures slightly elevated. Acanthopores commonly described as absent but distinct rounded clear spots occur at the junction angles. Diaphragms few in the (im), closely spaced in the (m). Mesopores absent. Seven-eight zooecia occur in 2 mm. The characteristic rhombic zooecia may be seen in deep tangential sections or the weathered tips of the branches.

A common and characteristic species of the Liberty and Whit.ewater.

RHOMBOTRYPA SUBQUADRATA. (ULRICH)

Pl. XVI, figs. 9, 10

A smaller ramose form than the preceding species with diameter 2-3 mm., characterized by the development of mesopores. Ulrich and Bassler (1904, p. 45) have pointed out that the "mesopores" are inter-zooecial spaces instead of tubes with walls of their own.

Waynesville and basal Liberty of the Cincinnati region.

FAMILY HALLOPORIDAE

GENUS HALLOPORA. BASSLER

Zoarium ramose. Diaphragms closely spaced in the tapering proximal end of the zooecia, few or wanting in the rest of the (im), crowded again in the (m). Closely tabulated mesopores more or less abundant.

HALLOPORA MULTITABULATA. ULRICH

Pl. I, figs. 5, 6

Zoarium of dendroid branches 7-8 mm. in diameter, with strongly elevated more or less conical monticules occupied by zooecia of about normal size. Zooecia thin-walled, direct. Mesopores few. Diaphragms abundant throughout the zooecial tubes, about 1 diameter apart in the (im) and several times as abundant in the (m).

Particularly common in the Jessamine but ranging up through the Woodburn.

HALLOPORA ONEALLI. (JAMES)
Pl. IX, figs. 10, 12

Zoarium dendroid, branches 1.5-2 mm. in diameter, frequently anastomosing. Surface smooth or with inconspicuous monticules. Zooecia thin-walled, apertures oval, 5-6 in 2 mm. Mesopores small, angular, abundant. Diaphragms moderately numerous in the proximal end, and closely spaced in the (m).

Common in the Economy member of the Eden, less common at higher levels

Several varieties are recognized:

var. *communis* (Pl. VIII, fig. 18;) ranging throughout the Eden but best developed in the McMickens, is of larger size, diameter about 7mm. The mesopores tend to pinch out toward the surface resulting in fewer showing on the surface and the zooecial apertures correspondingly more angular. It occurs also in the lower Million east of Winchester.

var. *sigillaroides,* (Pl. IX, figs. 13, 14) from the Eden, (all members) is distinguished on zoarial character. The branches are 4-5 mm. in diameter, do not anatomose, and bifurcate infrequently.

A recurrence of this species or closely related form in large numbers is found in the light colored clay at the top of the Oregonia. Cumings and Galloway (1913 faunal chart) show such an occurrence in the Tanner's Creek section in the Corryville-Arnheim and Waynesville.

HALLOPORA DALEI. (M. E. AND H.)
Pl. X, fig. 10

Distinguished from *H. ramosa* by its more slender zoarium and smaller monticules.

Common throughout the Fairview.

HALLOPORA RAMOSA. D'ORBIGNY
Pl. XIII, fig. 3

Zoarium dendroid, 3-8 mm. in diameter, with prominent conical monticules several mm. apart which are characterized by the more numerous mesopores. Mesopores small, angular, abundant, in some cases completely isolating the zooecia.

Particularly characteristic of the McMillan but ranging down in the upper Fairview.

HALLOPORA RUGOSA. (M. E. AND H.)
Pl. XIII, fig. 2

Distinguished from *H. ramosa* by the transversely elongate monticules often forming discontinuous ridges.

Characteristic of the McMillan, its best development above that of *H. ramosa.*

HALLOPORA ANDREWSI. (NICHOLSON)
Pl. XIII, fig. 11

Zoarium ramose 6-12 mm. in diameter. Surface typically with low rounded monticules composed of larger apertures and more numerous mesopores. Zooecia about 7 in 2 mm. surrounded by a variable number of angular or subcircular mesopores. Tabulation of zooecia variable. Bellevue and Corryville.

HALLOPORA SUBNODOSA (ULRICH)
Pl. XV, fig. 18

Zoarium dendroid, 6-12 mm. in diameter. Surface with low rounded monticules composed of apertures larger than normal and more numerous mesopores. Zooecial apertures circular, surrounded by a variable number of mesopores. Diaphragms numerous only in the proximal end of tubes, rare or absent above. Cumings (1908 p. 797) notes considerable variation in the tabulation.

A common Richmond fossil from the upper Waynesville up.

FAMILY TREMATOPORIDAE

GENUS BATOSTOMA. ULRICH

Zoarium irregularly ramose. Acanthopores usually large and numerous. Mesopores variable. Zooecia much thickened in the (m), in section appearing ring-like.

BATOSTOMA JAMESI. (NICHOLSON)
Pl. IX, fig. 20

Zoarium dendroid, the branches irregularly thickened and nodulose, 5-10 mm. in diameter. Apertures circular or oval, about 6 in 2 mm., separated by a series of mesopores. Acanthopores small, rather numerous. Diaphragms in the zooecia widely spaced.

From the associated *B. implicatum* it is distinguished by the greater development of mesopores, consequently more rounded

apertures, thinner walls, and smaller acanthopores. The latter forms flattened branches.

Both are characteristic Eden species, the latter ranging up into the Fairmount.

BATOSTOMA VARIANS. (JAMES)

Distinguished from *B. jamesi* (Bassler 1906, p. 18) by the thin-walled, angular zooecia, few mesopores, fewer diaphragms, and lobate to subfrondescent growth.

Common throughout the Richmond.

BATOSTOMA VARIABLE. ULRICH

Zoarium of smooth, cylindrical or subcompressed infrequently dividing branches with conspicuous maculae of larger zooecia. Zooecia thin-walled, polygonal, mesopores practically wanting. Acanthopores variable. Zooecia 6-7 in 2 mm. Characteristic of the Whitewater.

FAMILY PTILODICTYONIDAE

GENUS ESCHAROPORA. HALL

Zoarium a simple or branching frond articulating with a basal expansion. Zooecial apertures in diagonally intersecting series, surrounded by sloping hexagonal areas.

ESCHAROPORA RAMOSA. ULRICH

Zoarium ramose, branches acutely elliptical in cross-section, 3-6 mm. in width, with tapering articulating base. Apertures circular or elliptical 9 in 2 mm. along the diagonal rows. Margin nonporiferous.

Tyrone and Camp Nelson limestones.

ESCHAROPORA ACUMINATA. (JAMES)

Distinguished from *E. falciformis* by the more slender and comparatively thicker zoarium being compressed cylindrical rather than acutely elliptical in cross-section. Length, 1½-3 cm., width, 2-3 mm. Thickness 1-2 mm.

Eden from Cincinnati and vicinity. Bassler (1906, p. 36) notes that within the Eden there are all transitions to the broader forms of the typical *E. falciformis*. Similar forms occur also in the Greendale member of the Cynthiana at Lexington.

ESCHAROPORA FALCIFORMIS. (NICHOLSON)
Pl. XI, fig. 19

A thin, sharp edged, falciform frond. Length seldom over 50 mm., width usually less than 5 mm., thickness about 1 mm. Diagonal rows make an angle of about 60 degrees with each other and 30 with the edge of the frond. Occasionally a frond branches.

Fairview formation of Cincinnati and vicinity, occasionally also in the upper Eden. The Greendale member of the Cynthiana in Central Kentucky contains what is probably the same species.

ESCHAROPORA MACULATA. (ULRICH)
Pl. V fig. 10, 11; Pl. XI, fig. 18

A more robust form. Width up to 4 cm., length, 13 or more cm., thickness not exceeding 2-3 mm. It is characterized by the conspicuous, usually slightly elevated maculae several mm. apart, composed of larger apertures. Its growth may be falciform but more commonly it expands symmetrically from an articulating base.

Fairmount from Cincinnati and vicinity, and Greendale member of the Cynthiana in Central Kentucky.

ESCHAROPORA PAVONIA. (D'ORBIGNY)
Pl. X,, figs. 5, 6

A thin undulating expansion attaining much greater width and irregularity than *E. maculata.* Maculae relatively inconspicuous.

Fairview of Cincinnati and vicinity. It is also common in the basal Cynthiana of southwestern Fayette and adjoining-parts of Jessamine County.

ESCHAROPORA HILLI. (JAMES)
Pl. X, figs. 8, 9

An unbranched, flattened frond, gradually expanding from an articulating base commonly 1-2 cm. in width and up to 10 cm. in length. It is characterized by the development of more or less discontinuous transverse ridges (monticules) which do not interrupt the diagonal series of apertures.

Characteristic of the Fairmount of the southern Bluegrass. A closely related form occurs in the Cynthiana.

FAMILY RHINIDICTYONIDAE

GENUS RHINIDICTYA. ULRICH

Zoarium dendroid, of narrow, compressed, parallel edged branches continuous with an expanded base. Apertures in longitudinal rows.

RHINIDICTYA NEGLECTA. ULRICH

Pl. II, figs. 5, 6

Narrow branches 1.5-2 mm. wide, dividing at intervals of 4-7 mm. Zooecia in 9 (8-11) longitudinal rows, oblique with elliptical apertures, 16-18 in 2 mm. Six rows occur in the same distance. Interspaces comparatively thick, with a series of small grannules. Apertures of marginal rows directed outward in some specimens.

Common in the Lexington limestone, particularly the Jessamine, also rather common in the Cynthiana.

RHINIDICTYA. SP.

Associated with *Escharopora ramosa* in the upper beds of the Camp Nelson is a *Rhinidictya,* in growth essentially as in *R. neglecta,* but with conspicuous superior hemiseptum. There are 10-13 ranges of zooecia, 5-6 rows in 2 mm., and longitudinally 17 apertures in 2 mm. The marginal rows show the apertures directed slightly outward. Compared with *R. fidelis* the branches bifurcate more frequently, are a little wider with one or two more rows of apertures, and the zooecial tubes make a more acute angle with the median lamina.

PHYLUM MOLLUSCA

CLASS PELECYPODA

FAMILY CTENODONTIDAE

GFNUS CTENODONTA. SALTER

Shell equivalve, smooth or with concentric growth lines. Hinge arcuate, with series of curved, transverse teeth. Cardinal area not striated. Ligament small, immediately behind the beaks. Adductor impressions subequal. This genus is abundantly represented in the local Ordovician.

FAMILY PTERINEIDAE DALL

GENUS PTERINEA. GOLDF

Left valve convex, right flat, inequilateral, auriculate anteriorly and posteriorly. Area amphidetic, grooved longitudinally. Anterior teeth obscure, transverse, posterior elongate, nearly parallel to the cardinal margin. Posterior adductor scar large, anterior small, strong, located below the anterior wing.

PTERINEA DEMISSA. (CONRAD)

Distinguished by the strong concentric growth lines and large anterior ear (Grabau and Shiner 1909, p. 419). Measurements of a typical specimen—hinge line 42 mm., beak to center of base along oblique umbonal ridge 37 mm., beak about one-third distance from the anterior end.

Common in the Maysville and Richmond.

FAMILY AMBONYCHIIDAE

GENUS BYSSONYCHIA. ULRICH

Equivalve, inequilateral, more or less winged posteriorly with beaks nearly or quite terminal. Valves ventricose, with byssal opening in the upper half of the anterior side, and marked by moderately strong radiating ribs. Two or three slender lateral teeth and several cardinals are present. Ligament external. Area striated.

BYSSONYCHIA RADIATA. HALL

Shell obliquely ovate, extending into acute curving beaks. Surface with about 45 radiating plications. Length of average specimen about 40 mm., greatest width about 3/4 length, convexity about 1/6 length. Anterior slope nearly straight making an angle of a little less than 90 degrees with the cardinal margin. Posterior angle quite obtuse rounding more or less gradually into the cardinal outline. Cardinal margin about one-half the greatest length of shell. Maysville and Richmond.

GENUS ALLONYCHIA. ULRICH

Distinguished from *Byssonychia* in the absence of cardinal and lateral teeth. It is more erect, than other *Ambonychia*-like forms, (Grabau and Shimer 1909, p. 432) and with no posterior alation.

ALLONYCHIA FLANAGANENSIS. FOERSTE
Pl. VII, fig. 1

This species is characterized by the long hinge line and the very oblique anterior and posterior margins, producing an elongate rather than erect form. The shell is strongly convex, the anterior slope of the more gibbous specimens practically vertical except for the protrusion of the bysal opening. Shell thick, radiating plications very flat and separated by very narrow and shallow grooves, readily overlooked. Measurements given by Foerste are: length 11 cm. from beak along the umbonal ridge, hinge area 6/2 cm. in length extending 5-8 mm. anterior to the beak. Hinge area 4-6 mm. high.

Very common in and characteristic of the Cynthiana, particularly the Millersburg phase.

GENUS ANOMALODONTA. MILLER

Distinguished from Byssonychia in the absence of cardinal and lateral teeth. Distinguished from *Allonychia* in the more oblique form and strong posterior alation.

ANOMALODONTA GIGANTEA. MILLER

An unusually large pelecypod 8-10 cm. in length and almost as wide, alate posteriorly and marked by 30-40 strong radiating ribs. Anterior edge about at right angles to hinge line. Beaks sharp, slightly incurved, and situated at the anterior end of the cardinal margin. Byssal opening immediately below the beak, 6-7 mm. in diameter. In a specimen 8 cm. long the hinge has a length of about 5 cm. From 4-14 cartilage grooves extend from the end of the wing to the byssal opening.

A characteristic Richmond species known from the Arnheim to the Whitewater. In the region around Louisville it seems to be restricted to the Arnheim.

FAMILY MODIOLOPSIDAE

GENUS MODIOLOPSIS. HALL

Shell thin, obliquely elongate very inequilateral, with small anterior and large posterior end. Beaks not prominent, near anterior end. Valves crossed by oblique depression extending backward from anterior portion of umbo, and marked by con-

centric lines of growth. Teeth absent. Anterior adductor scar large and deep, posterior one large but faint. Ligament chiefly external.

MODIOLOPSIS MODIOLARIS. (CONRAD)

The principal features are the comparatively straight hinge line posterior to the beak, a moderately convex or nearly straight basal margin, absence of median sulcus, and conspicuous extension of the anterior margin of the shell in front of the beaks. The umbonal ridge disappears ventrally in the general convexity of the shell. Measurements after figures by Foerste (1914b, p. 282) are: length about 60 mm., height at beak about 1/3 length, height posteriorly about ½ length, beaks 10-11 mm. behind anterior margin; convexity of valve about 4 mm., angle between cardinal and ventral margin 11-12 degrees.

Maysville and Richmond.

MODIOLOPSIS CONCENTRICA. HALL AND WHITFIELD

About 2/3 the size of *M. modiolaris* with concentric lines which become obsolete on the umbonal ridge. The basal margin is a little concave and the anterior end extends but little beyond the beaks.

Waynesville of the Cincinnati region.

GENUS MODIOLODON. ULRICH

Modioliform shells distinguished from *Modiolopis* by the presence of 2-3 cardinal teeth in each valve.

A common genus from the Black River to the Richmond.

CLASS GASTROPODA

FAMILY CYRTOLITIDAE

GENUS CYRTOLITES. CONRAD

Volutions 2 or 3, gradually enlarging, scarcely contiguous. Carinated on the back, often on the sides, giving subquadrate cross section. Aperture with or without median notch in outer lip, no slit band. Shell without callosities. Surface reticulated or cancellated.

CYRTOLITES ORNATUS. CONRAD

Average shell 20-25 mm. in diameter, of 2 or 3 strongly carinated volutions, rhombic-subquadrate in cross-section, and rapidly expanding. Side subangular or narrowly rounded, the

dorsal slope gently convex with strong transverse furrows and subangular ridges, the umbilical slope almost flat, without undulations. Ventral side with sharp impressed zone. Umbilicus wide and deep. Surface marked by raised transverse lines with short connecting lines in alternating series. In the outer part of the last whorl there are commonly 7-8 of the transverse, and 8-9 of the short lines in 2 mm. There is no perceptible recurving of the transverse lines in crossing the dorsal carina.

Maysville and Richmond. A small variety, *C. ornatus* minor with a diameter not in excess of 11 mm. occurs in the Trenton of Minnesota and elsewhere.

FAMILY BUCANIIDAE

GENUS SINUITES. HALL

This genus includes those forms which have commonly gone under the name of *Protowarthia,* a synonym. It is distinguished from *Bellerophon* in the absence of the slit band, in the lack of abruptly expanded aperture, and presence of revolving striae as well as growth lines.

SINUITES CANCELLATA. (HALL)

The most common of the Ordovician Bellerophontids characterized by the evenly rounded dorsum, rounded apertural lobes, and moderately deep sinus which is *U*- rather than *V*-shaped. Surface marked by fine lines of growth crossed by fine revolving striae. The surface features are seldom preserved. Diameter up to about 25 mm., height about 4/5 diameter. Trenton to Richmond.

GENUS OXYDISCUS. KOKEN

A Bellerophontid characterized by the lenticular form, compressed, sharply keeled volutions which expand gradually to the aperture. Outer lip with F-shaped excission continuing as a long and verv narrow slit. Inner lip without callosity. Surface with growth lines only, in which feature it is not typical of the *Bucaniidae.*

OXYDISCUS SUBACUTUS. (ULRICH)

Shell from 15-30 mm. in diameter. Thickness about ½ diameter. Volutions 3½-4½, each embracing 1/3-1/2 of the preceding. Umbilicus 1/3 or less the diameter of the shell,

with abrupt, subangular edge exposing all volutions. Aperture obcordate, indented below by the sharp dorsum of the preceding whorl. Surface concave bordering the sharp periphery and marked by fine rather indistinct lines of growth.

Lexington limestone, particularly common in the Faulconer.

FAMILY BELLEROPHONTIDAE

GENUS BELLEROPHON. MONTFORT

Shell subglobose. Umbilicus never large. Aperture generally expanded, with callosity on inner lip. Outer lip with central notch and with well developed slit band or elevated blunt keel. Surface with growth striae only.

BELLEROPHON TROOSTI. D'ORBIGNY

Pl. IV, fig. 8

Shell rarely exceeding 17 mm. in diameter, aperture flaring laterally, diameter somewhat in excess of height. Adult forms with rounded carina, surface flat or slightly excavated, in younger forms, with distinct slit band. Notch deep, rather narrow subrectangular. Fine growth lines approach the slit band nearly at right angles and are then abruptly deflected backward.

A common Trenton species, particularly abundant in the Faulconer.

GENUS LOPHOSPIRA. WHITFIELD

Spire more or less elevated. Whorls closely coiled, angular on the periphery, generally with several carinae, the peripheral one strongest. Umbilicus small. Outer lip more or less deeply notched, but no slit. Surface markings of growth lines.

LOPHOSPIRA BOWDENI. SAFFORD

Height 45-50 mm., volutions 8-10, moderately angular with thick subcentral peripheral band. Upper slope more or less concave in the lower half, upper half convex, sometimes obscurely carinate. Lower carina obscure, space above a little concave. Apical angle 25-35 degrees. Umbilicus minute covered by reflected inner lip in the narrow specimens. Surface with unequal growth lines, strongly recurved toward the peripheral band indicating a deep F-shaped notch. Common through the Trenton-Richmond.

LOPHOSPIRA MEDIALIS. ULRICH
Pl. IV, fig. 9

Height 12-22 mm., apical angle 60-65 degrees with 6-7 volutions. Upper slope nearly flat. Lower carina never strong, the slope between it and the strong peripheral carina more or less concave. Band rounded, with growth lines strongly recurved toward it. Umbilicus small.

Common in the Lexington series.

LOPHOSPIRA PERANGULATA. HALL

Distinguished from *L. medialis* by the smaller apical angle (usually about 52 degrees), lower carina more distinct, and the last volution tending to become free. Peripheral band prominent, sharp, trilineate. Surface markings of stronger growth lines with finer in between.

High Bridge and Lexington series.

GENUS LIOSPIRA. ULRICH

Shell sublenticular, subconical, sharply rounded at the periphery, almost smooth. Suture close, scarcely distinguishable. Umbilicus often filled by reflected inner lip. Aperture deeply notched, band obscure. Surface markings of growth lines and spirals.

LIOSPIRA MICULA. HALL

Small, diameter 11-12 mm., height about ½ diameter, of usually four volutions, with shallow suture, the upper surface forming an almost even slope. Umbilicus filled by reflection of inner lip. Surface markings of fine growth lines and exceedingly fin spirals. The former are strongly deflected backward along the slit band which is located on the upper edge of the periphery. Inner lip essentially vertical in the Trenton forms, always more so than in the later forms.

Trenton-Richmond.

LIOSPIRA VITRUVIA. BILLINGS

Diameter about 25 mm., height about ½ diameter. Characteristic features are the open umbilicus with angular margin and flattened sides, and the unusually prominent and sharply curved outline of the lower lip. Upper side of last whorl a little concave because of the slight elevation of the peripheral band.

Black River-Richmond.

LIOSPIRA MUNDULA. ULRICH

A small species about 12 mm. in diameter and 7 mm. high, of 4-5 volutions, distinguished by the thick ridge above, adjoining the suture, the elevated band on the upper edge of the periphery, and concave surface between. Umbilicus open. Base uniformly rounded.

Trenton.

LIOSPIRA AMERICANA. BILLINGS

Pl. II, fig. 4

Diameter 30-40 mm. distinguished from *L. vitruvia* by the broader curvature of the lower lip which is like that of *L. progne, L. micula,* etc., and the broader and less abrupt umbilicus without the angulation as in that species. With specimens commonly preserved in the Lexington limestone as molds, these criteria are difficult to apply. According to Ulrich, *L. vitruvia* has commonly been identified as this species.

Specimens of this type are very common in the Jessamine but seldom preserving the diagnostic features.

Stones River-Richmond.

LIOSPIRA PROGNE. BILLINGS

Distinguished from *L. micula* only in size, with diameter 25-35 mm. and from *L. americana* in the closing of the umbilicus which is more or less filled with shell material. In internal molds where the umbilicus is occupied by the same material filling the whorls the umbilicus was open. For this reason *L. americana* and *L. vitruvia* seldom have the umbilical cavity entirely free of the matrix material.

Stones River and Trenton.

FAMILY EUOMPHALIDAE

GENUS MACLURITES. LESUEUR

Shell sinistral discoidal, upper surface flat showing all of the few, rapidly enlarging whorls. Base convex, and strongly umbilicated. Surface marked by growth lines, revolving lines sometimes shown in the peripheral region. Ulrich and Schofield (1897, p. 1038) regard the shell as dextral with the flat surface the base.

MACLURITES BIGSBI. HALL

Pl. I, fig. 10

Shell 50-60 mm in diameter, height, /4 diameter. Umbilicus deep, rather abrupt, from one-third to one-half the diameter of the shell in width, exposing half or more of the inner whorls. Operculum with nucleus at the inner angle.

Camp Nelson.

FAMILY TROCHONEMATIDAE

GENUS CYCLONEMA. HALL

Shell turbinate, non-umbilicated, with short spire, composed of few more or less ventricose whorls. Aperture oblique with reflected inner lip, always excavated. Surface with spiral lines and small ridges crossed obliquely by sharp lines of growth.

CYCLONEMA VARICOSUM. HALL

Pl. V, fig. 6

Distinguished from the *C. bilix* type by the more ventricose whorls and stronger surface markings. The curvature is uniformly convex with no sign of a shoulder at the suture. The revolving ridges are strong and between each pair there are usually several finer ones. Nine or ten of the principal carinae occur on the body whorl, five or six exposed on the higher whorls. Volutions never exceeding five. Suture deep.

Characteristic of the Cynthiana, particularly the Greendale and Millersburg phases. A small variety occurs in the Rogers Gap.

CYCLONEMA MEDIALE. (ULRICH)

Distinguished from *C. varicosum* by the less convex whorls, shallower suture, and more slender spire with six to seven whorls. The surface markings are weaker and the columnar lip not as straight. Revolving lines either subequal or stronger ones with several weaker ones in between.

The common species of the Maysville.

CYCLONEMA BILIX. CONRAD

A turbinate shell, with height equal to or a little greater than width. Apical angle 55-75 degrees. Whorls 2 to 4, depressed convex, flattened or even a little concave centrally on the exposed outer part, with a shoulder-like convexity at both

top and bottom giving a deeply impressed suture. Base of last whorl more or less flattened, narrowly rounded at the periphery. Surface with subequal revolving striae on the upper whorls, generally alternating on the body whorl, crossed diagonally by finer growth lines. These are exceptionally fine for the genus, about 12 in 2 mm. on the last whorl, 9-12 ridges occur on the exposed part of the upper whorls. On the body whorl about, 4 in 2 mm.

This is the common *Cyclonema* of the Richmond.

CYCLONEMA BILIX VAR C. FLUCTUATUM. (JAMES)

Pl. XIV, fig. 16

A variety distinguished by the much finer surface markings and almost constant concavity of the outer part of each whorl. The lower whorl commonly shows a series of transverse undulations but this feature is not constant nor restricted to it. Rather characteristic of the Arnheim in the western area of out-crop in Kentucky, from the Arnheim and Waynesville in Ohio and Indiana, possibly also the Whitewater.

GENUS CYCLORA. HALL

Minute spiral shells of rounded whorls loosely embracing so as to leave a deep suture and umbilicus. Surface smooth. Aperture circular, lip thin.

CYCLORA MINUTA. HALL

"Subglobose, wider than high, with much depressed spire of three rapidly increasing volutions; suture almost channeled; umbilicus small. Possibly pelagic protoconchs of other gastropods." (Grabau and Shimer, 1909, p. 673.)

Very common throughout the Trenton-Richmond. In Central Kentucky it is particularly common in the Woodburn where its occurrence is genetically related to the phosphate deposits.

FAMILY PYRAMIDELLIDAE

GENUS FUSISPIRA. HALL

Shell fusiform, whorls convex or flat. Aperture elongate oval, acuminate above, canaliculate below. Columella nearly vertical, slightly twisted, thin. Surface smooth or with revolving or longitudinal rows of small punctures.

FUSISPIRA SULCATA. ULRICH
Pl. VIII, fig. 17

Shell thick, of about 6 gradually expanding very depressed convex whorls the last forming about 2/5 the entire height of the shell. Apical angle about 32 degrees. Suture faint externally, deep in molds. Aperture elongate, obliquely subelliptical, somewhat acuminate at both ends. Surface smooth except for revolving rows of very fine punctae. Surface of molds with several more or less obscure revolving furrows. Height of average specimen 6-7 cm.

Specimens referred to this species are rather common in the Rogers Gap, the types coming from the type locality at Rogers Gap, Grant County.

CLASS CEPHALOPODA

FAMILY ENDOCERATIDAE

GENUS ENDOCERAS. CONRAD

Othocones with large, more or less eccentric siphuncle, the funnels extending only to the next preceding septum.

ENDOCERAS PROTEIFORME. HALL
Pl. I, fig. 11

E. proteiforme is characterized by its enormous size, sometimes attaining a length of 10-15 feet, circular section, comparatively shallow chambers, and large submarginal siphon. The spacing of the septa increases toward the body chamber. Relative diameters of the shell and siphuncle in available specimens about 2:1.

A wide-spread and common species throughout the Mohawkian and Cincinnatian.

FAMILY ACTINOCERATIDAE SAEMANN

GENUS ACTINOCERAS. BRONN.

Orthoceracones and *cyrtoceracones,* depressed elliptical in section, characterized by the large, nummuloidal siphuncle, short compressed funnels, and nearly globular sheaths. Septa often double.

ACTINOCERAS BIGSBYI. STOKES

Pl. I, fig. I

A large species with deeply concave septa. Siphuncle excentric, large, the siphonal beads occupying fully two thirds the diameter of the shell. Endosiphonal walls thick.

Tyrone.

FAMILY ORTHOCERATIDAE

GENUS ORTHOCERAS. BREYN

Long slender, usually tapering orthoceracones with small central or subcentral siphuncle. Shell smooth or with transverse striae.

ORTHOCERAS DUSERI. HALL AND WHITFIELD

A rather rapidly expanding shell, circular in section, typically about 20 cm. in length, expanding from 5 to 35 mm. Septa moderately concave, closely spaced, less so toward the living chamber where 10 chambers in the above specimen occur in 40 mm. Siphuncle eccentric somewhat nearer center than margin, very small where passing through the septa, expanding to about 4 times that diameter within each chamber. Surface smooth except for the raised edges of the septa which form narrow rings and the presence opposite the siphuncle of a narrow raised longitudinal line extending the length of the shell, slightly interrupted just above each of the annular rings.

An important horizon marker at the top of the Fort Ancient member of the Waynesville, known as the *0. "fosteri"* horizon. It is listed by Cumings from the McMillan and lower Arnheim of Indiana.

CLASS TRILOBITA

FAMILY TRINUCLEIDAE EMMRICH

GENUS CRYPTOLITHUS. GREEN

Cephalon very broad proportionately with long genal spines, and broad, regularly pitted border. Glabella inflated, pear-shaped, smooth or with indistinct furrows. Eyes generally absent. Thorax of 6 segments which are nearly straight at their extremities; axis narrow. Pygidium with margin entire. (Grabau and Shimer 1909, p. 258))

CRYPTOLITHUS TESSALATUS. GREEN

Pl. IX, fig. 19

Head semicircular or subcrescentic, typically about, 10 mm. long, 15 mm. wide, convexity of about 6 mm. Genal angles with or without spines. Glabella smooth, very prominent, produced posteriorly into a short, blunt spine. Anterior and lateral margins surrounded by a broad flattened border, marked by 3-5 concentric rows of deep rounded pits in front and one or two additional rows laterally, becoming irregular toward the genal angles. More familiarly known as "Trinucleus concentricus."

Particularly common in the Eden,, also in the Cynthiana. It is listed by Nickles from the Point Pleasant beds (1902, p. 64). It occurs in large numbers thirty feet above the Cornishville and about 75 feet below the *Plectambonites* layers of the Million in Lincoln and Boyle counties.

FAMILY OLENIDAE

GENUS TRIARTHRUS. GREEN

Elliptical. Cephalon semicircular. Glabella large and well defined with straight sides and rounded front, marked by three deep furrows extending toward the center from each side. Eyes small. Central axis of thorax wider than lateral lobes; furrows of axis not continuous with those of pleura. Thoracic segments 14-16. Pleural segments grooved. Pygidium with 6 segments in the axis and with entire margin. (Grabau and Shimer, 1910, p. 286)

TRIARTHRUS BECKI. (EATON)
Pl. IX, fig. 9

Length about 20 mm., width, 0.5 length. Center of each axial segment marked by a tubercule.

A characteristic Fulton species, recurring in the Southgate.

FAMILY ASAPHIDAE BURMEISTER

GENUS ISOTELUS. DEKAY

Isotelus belongs to the subfamily Asaphinae with bifurcated hypostome. Carapace oval with broad axial lobe, and obsolete segmentation of pygidium and glabella. Eyes large and prominent. Thorax of eight segments, pleura grooved, with rounded extremities. Free cheeks large, the suture emerging well within the genal angles.

ISOTELUS GIGAS. DEKAY

A large species commonly attaining a length of 200-250 mm., at times practically double the figure. Width somewhat over half the length. Axis forming about one-half the width. The most distinctive feature is the subtriangular form of the pygidiurn with length about 3/4 width. Cephalon similarly subtriangular. Genal spines short, present only on the smaller specimens.

Mohawkian and Cincinnatian.

ISOTELUS MAXIMUS. LOCKE

This species has commonly been distinguished from the preceding by the development of genal spines extending back as far as the fifth or sixth thoracic segment. According to Raymond and Narraway (1910, p. 55) the pygidium is short and rounded, contrasting with the subtriangular form of *I. gigas.* In this it agrees with the young individuals of that species. It does not attain the large size of *I. gigas.*

Trenton-Richmond.

CLASS OSTRACODA

FAMILY LEPERDITIIDAE JONES

GENUS LEPERDITIA. ROUAULT

Shell large, suboblong with oblique backward swing. Ventral outline rounded, greatest thickness ventrally, lower edge usually blunt. Right valve overlapping the left ventrally. Hinge simple. Surface frequently horny, smooth and glossy, in some specimens grannulose or punctate. Eye spot usually present on antero-dorsal fourth. Large, rounded, subcentral muscle scar well marked on the interior, sometimes discernible externally.

LEPERDITIA CAECIGENA. S. A. MILLER

Shell obliquely subovate, length about 3 mm., width 2/3, and thickness 1/3 length. Anterior end but little produced beyond hinge, posterior end protruding about one-third the length of the shell. Anterobasal margin sloping abruptly. Otherwise much like *L. fabulites.* Eye tubercule obsolete.

Whitewater-Saluda.

LEPERDITIA CAECIGENA VAR. FRANKFORTENSIS. ULRICH

Pl. IV, fig. 14

A variety distinguished in that it "has the dorsal angles sharper, an appreciably flattened border or flange at the ends of both valves and the ventral edge is a trifle more convex. The eye tubercule, and the reticulated spot as well, is, though always very small, generally distinguishable." (E. O. Ulrich, 1890, p. 177.)

Common in the Salvisa member of the Perryville.

LEPERDITIA FABULITES. CONRAD

Shell obliquely subovate, length 10-11 mm., height, and length of hinge about 2/3 length, thickness about 4 mm. Height of ends about as three is to four, both obliquely and about equally truncate above, the anterior end narrowly and posterior end more broadly curved. Ventral edge gently rounded, overlap strongest ventrally. Eye tubercule faint.

Tyrone and Curdsville.

GENUS ISOCHILINA. JONES

Distinguished from *Leperditia* in the equal non-overlapping valves.

ISOCHILINA JONESI. WETHERBY

Pl. IV, fig. 10

An average large specimen shows the following measurements: Length 20 mm., width 13 mm. Length of hinge 14mm. In available specimens the length varies from 8-25 mm. Posterior end more produced than anterior, hinge extremities slightly mucronate. Eye spot sharp, near dorsal margin.

Developed in great numbers in the Salvisa, particularly where the rock is more granular and somewhat argillaceous, associated with several species of *Leperditia*.

FAMILY BEYRICHIIDAE GENUS CTENOBOLBINA. ULRICH

Shell oblong or subovate, posterior two-fifths bulbous or subglobular, bordered anteriorly by a deep, obliquely curved sulcus which extends from the dorsal margin more than half way across the valves postero-ventrally. Anteriorly another oblique, but shallower sulcus. Dorsal margin long and straight,

hingement simple. Ventral edge thick, contact margin generally with a row of small spines on each side, and concealed on lateral view by an extended, flattened border.

CTENOBOLBINA CILIATA. (EMMONS)
Pl. VIII, fig. 19

Shell subovate, length 1½-2 mm., width 2/3 length, length of hinge 3/4. Anterior and posterior widths subequal, curvature of the two ends much alike, the posterior end curves in farther dorsally making a more acute angle with the hingeline. Posterior sulcus crescent shaped, narrow and deep. Anterior sulcus not so well defined. No eye tubercule. Surface minutely granulose.

A common Eden form, particularly characteristic of the Southgate member.

ILLUSTRATIONS OF ORDOVICIAN FOSSILS

Explanation of Plate I

(High Bridge and Lower Lexington)

Figure

1. *Actinoceras bigsbyi* Bronn. (1681a) X ½, Tyrone, Jessamine County, Kentucky.

2-4. *Orthis tricenaria* Conrad. (527c) Upper Black River, near Little Current, Ontario, Canada.

5-6. *Hallopora multitabulata* (Ulrich). (2090) Lower Jessamine or Hermitage, Elk Licks Falls, about twelve miles southeast of Lexington, Kentucky.

7-8. *Dinorthis pectinella* (Emmons). (2056) Curdsville formation, Mercer County, Kentucky.

9. *Strophomena incurvata* (Shepard). Tyrone limestone, High Bridge, Kentucky. After Foerste, Bul. Sci. Lab. Dennison Univ. Vol. 17, Pl. XI, fig. 7, 1912.

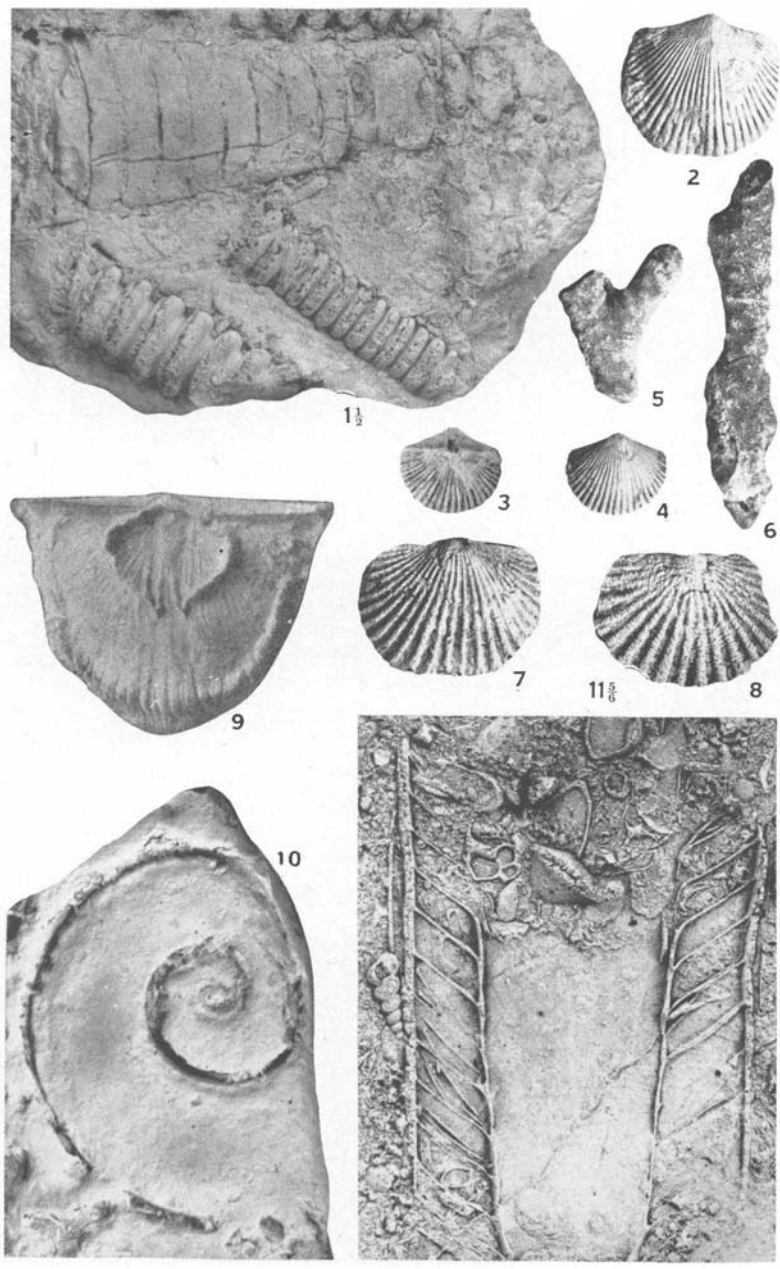
10. *Maclurites bigsbyi* Leseur. (850) Camp Nelson limestone, Jessamine Creek, Jessamine County, Kentucky.

11. *Endoceras proteiforme* Hall. (2081) x 5/6 Top of Jessamine formation, about a mile southwest of Spears, southeastern Jessamine County, Kentucky.

ACKNOWLEDGMENT

The writer is indebted for loans and gifts of specimens not available in the collection of the University of Kentucky to Dr. Wm. H. Shidler, Dr. George B. Twitchell, Dr. Walter H. Bucher, and Charles H. Faber.

PLATE I



Fossils of the High Bridge and Lower Lexington—Ordovician

Explanation of Plate II

(Lexington)

Figure

1-3. *Dalmanella bassleri* Foerste. Fig. 1 (2070) lower Hermitage, near Union Mills, Jessamine Co.; Figs. 2-3 (2072) Jessamine, three-fourths mile south of Downing Lane, Hickman Creek fault zone, Jessamine County, Kentucky.

4. *Liospira americana?* Billings. (2083) Jessamine, from quarry about 12 miles southeast of Lexington on Richmond road.

5-6. *Rhinidictya neqlecta* Ulrich. (2086) Jessamine, from quarry eight miles south of Lexington, Stop 17 on Nicholasville Interurban.

7-8. *Heterorthis clytie* Hall. (563) Hermitage, Frankfort, Ky.

9-10. *Strophomena vicina* Foerste. Fig. 9, (2069) Brannon, Armstrong Mill Pike and DeLong road, Fayette Co.; fig. 10, (2057) top of Benson, near Lexington.

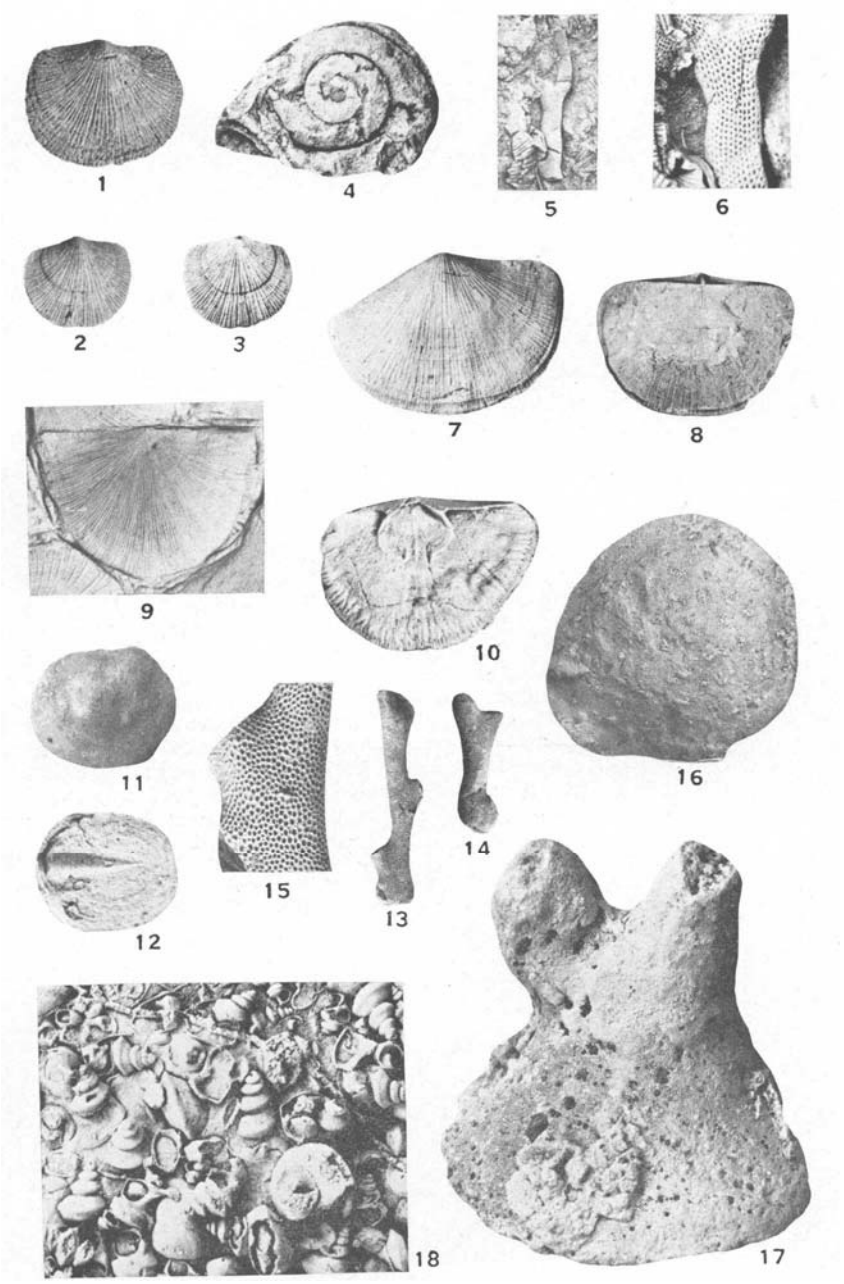
11-12. *Prasopora falesi* (James). (2068) Jessamine, 70-80 feet above Tyrone, Chenault bridge section at Dix River crossing on Lexington-Danville road.

13-15. *Eridotrypa aedilis* (Eichwald) (2075) Jessamine, four miles north of Wilmore on Lexington-Harrodsburg road. Fig. 15, lower part of 13, x 3. (See VIII, 13).

16-17. *Prasopora simulatrix* Ulrich. Fig. 16, (2071) Jessamine, along road from Duncan Station to Glen Creek southwest of Frankfort, Ky. Fig. 17, (2077) Jessamine, four miles north of Wilmore on Lexington-Harrodsburg road.

18. *Gastropod bed* at top of Jessamine, a mass of Lophospira, Ctenodonta etc., (2085) from quarry 2½ miles south of Lexington along Tates Creek Pike.

PLATE II



Fossils of the Lexington Limestone—Ordovician

Explanation of Plate III

(Lexington)

Figure

1-3. *Hebertella frankfortensis* Foerste. Figs. 1, 2 (2054) Cornishville member of Perryville, Burdett Knob, Garrard County, Ky. Fig. 3 (533) Benson, Franklin County, Ky.

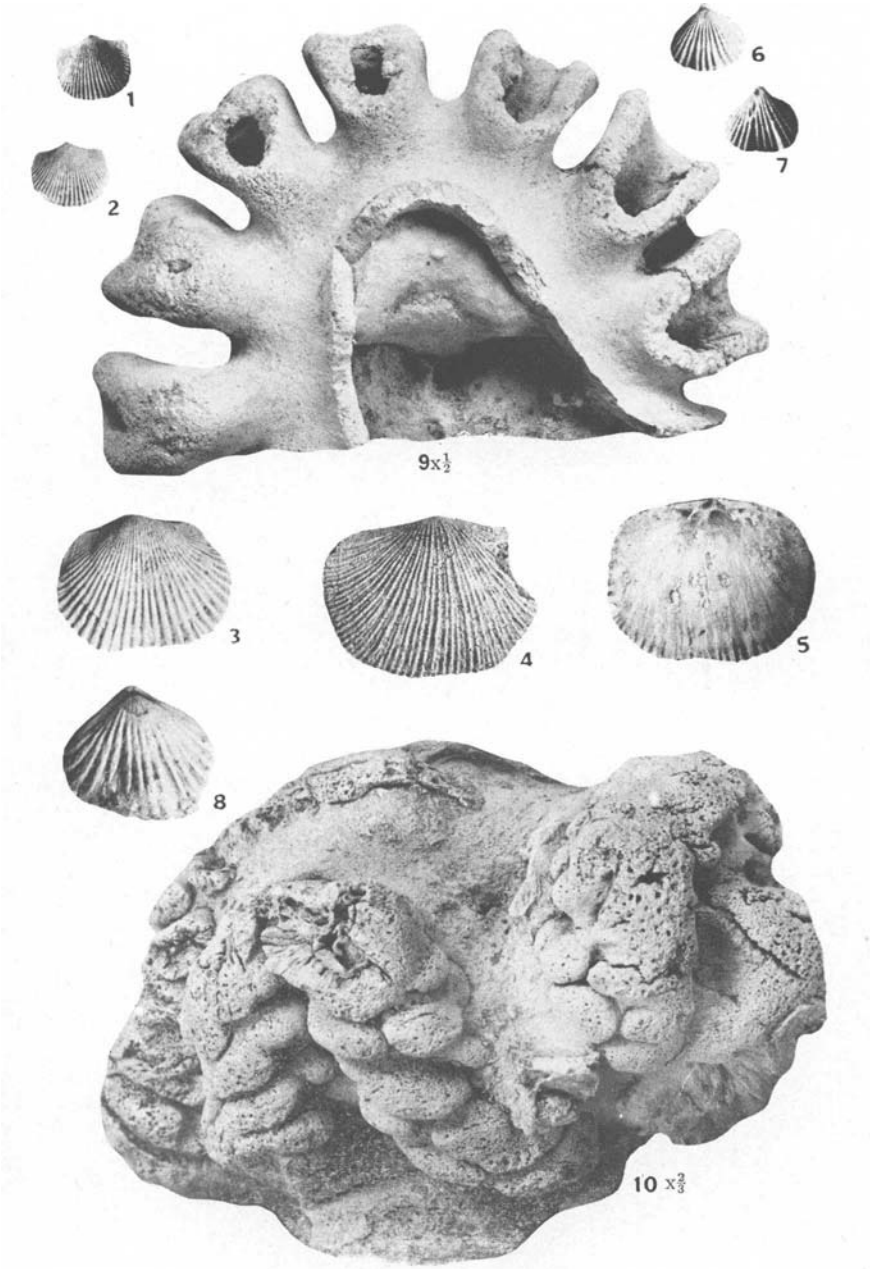
4-5. *Dinorthis ulrichi* Foerste. (1725b) Top of Benson, three miles south of Lexington on Tates Creek Pike.

6-8. *Rhynchotrema increbescens* (Hall) Figs. 6, 7, (2063) Jessamine, 70-80 feet above Tyrone limestone, Chenault bridge section, Lexington-Danville Road. Fig. 8, (2055) Faulconer, railroad cut northwest of Danville.

9. *Brachispongia digitata* (Owen). (2336) x ½ Brannon formation, Franklin County, Kentucky. (See IV, 1, 2).

10. *Pattersonia aurita* (Beecher) (599b) x ⅔ Brannon, A. M. Peter farm, northern Fayette Co., Kentucky.

PLATE III



Fossils of the Lexington Limestone—Ordovician

Explanation of Plate IV

(Lexington)

Figure

1- 2. *Brachiospongia digitata* (Owen) (2052) 1, view of specimen sawed in half, X 0.6 fig. 2, photomicrograph X 20 of section tangential to one of the arms. (See III, 9).

3- 4. *Platystrophia colbiensis* Foerste. (2059) Woodburn, Duncan station on Lexington-Frankfort Interurban, northern Woodford County. (See VII, 4, 5).

5. *Columnaria halli* Nicholson. (2096) Woodburn, Downing Lane and Tates Creek Pike, Fayette County.

6. *Columnaria alveolata* Goldfuss, showing the septa in longitudinal section. (2338) Woodburn Armstrong Mill road, ½ mile east of Tates Creek Pike, Fayette Co., Ky. (See XVI, 13).

7. *Hindia parva* Ulrich. (2058) Woodburn, Duncan Station on Lexington-Frankfort Interurban northern Woodford County.

8. *Bellerophon troosti* D'Orbigny (818) Faulconer member of the Perryville, Woodford Co., Ky.

9. *Lophospira medialis* Ulrich and Scofield. (2080), Faulconer member of Perryville formation, railroad cut three miles southeast of Versailles.

10. *Isochilina jonesi* Wetherby. (2087) Salvisa member of the Perryville, Woodford County, Kentucky.

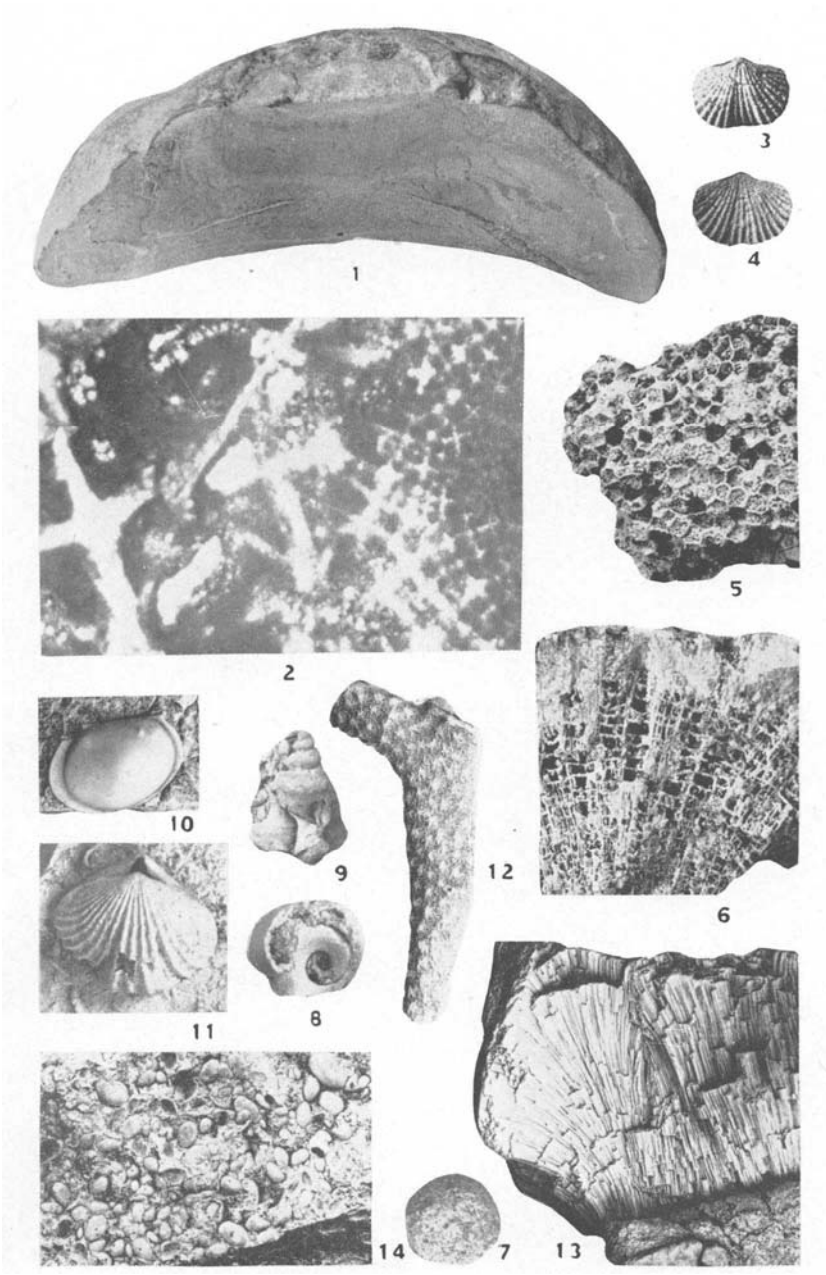
11. *Orthorhynchula linneyi* (James) (2060). Salvisa member of Perryville, Jonesboro, three miles south of Lexington on Tates Creek Pike. (See XI, 13).

12. *Constellaria teres* Ulrich and Bassler. (2093) Woodburn, Old Crow Distillery section about four miles southeast of Frankfort.

13. *Cyphotrypa frankfortensis* Ulrich and Bassler. (2082) Top of Benson, quarry at Bryan Station about four miles northeast of Lexington.

14. *Leperditia caecigena* var. *frankfortensis* Ulrich. (956) Salvisa member of Perryville, Mercer County, Kentucky.

PLATE IV



Fossils of the Lexington Limestone—Ordovician

Explanation of Plate V

(Cynthiana)

Figure

1- 2. *Hebertella occidentalis* Hall (2009) Cynthiana formation, Colby Station, C. and O. R.R. West of Winchester.

3- 4. *Hebertella subjugata* (Hall) (2009) Cynthiana, Nicholas Co., Ky.

5. *Eridotrypa briareus* (Nicholson) (1975) Cynthiana (Greendale), Southern RR. cut at Stone Road crossing three miles south of Lexington.

6. *Cyclonema varicosum* Hall. (1988) Cynthiana (Greendale), L. and E. RR. cut, Lexington.

7. *Rafinesquina alternata* (Emmons) (1999) Cynthiana, near Buckeye, Garrard County, Ky.

8- 9. *Rafinesquina winchesterensis* Foerste. (2237) Cynthiana, near Camp Nelson, Jessamine County. (See VIII, 14).

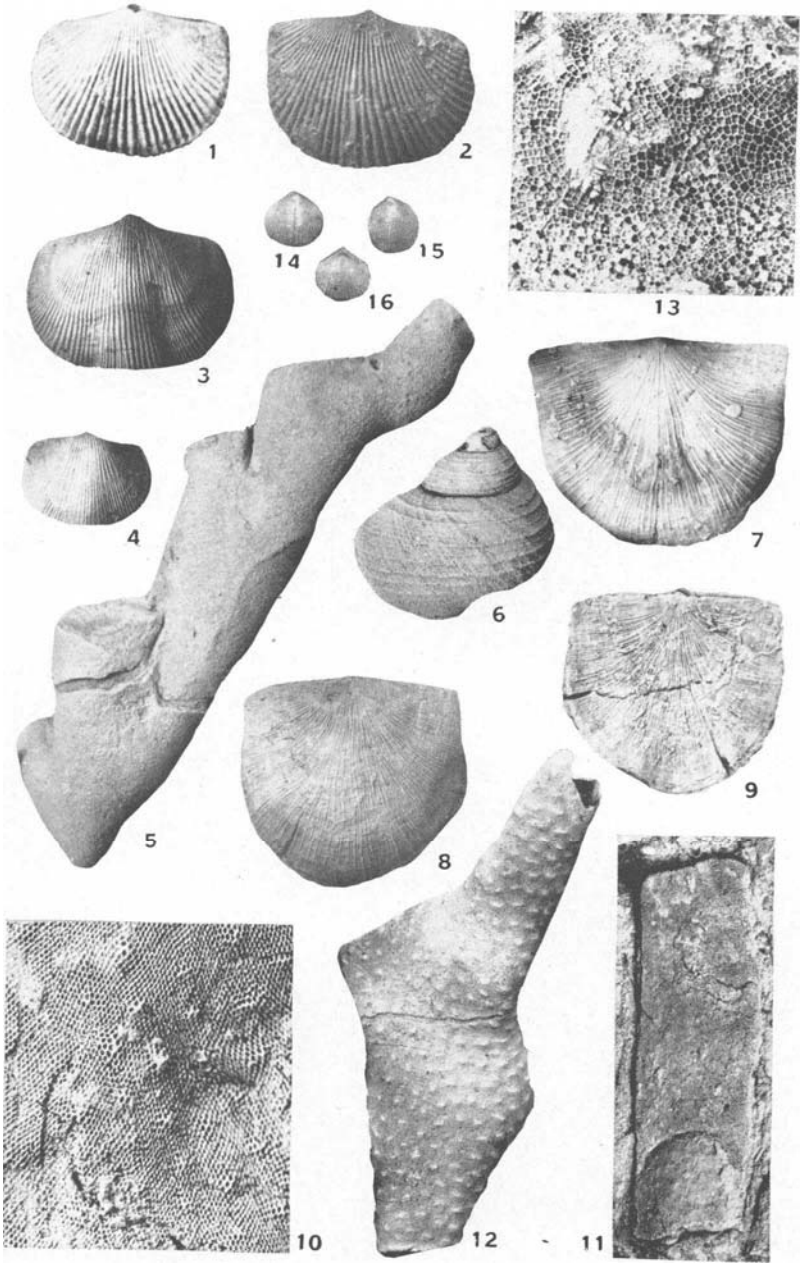
10-11. *Escharopora maculata* (Ulrich) (1981) Cynthiana, quarry 6½ miles east of Winchester on Mt. Sterling Road. Fig. 10, x3. (See XI, 18).

12. *Homotrypa norwoodi* (Nickles) (1982) Cynthiana, quarry 6½ miles east of Winchester on Mt. Sterling road.

13. *Tetradium fibratum* Saflford (1992) Cynthiana, upper part of quarry, Cynthiana, Harrison County, Ky.

14-16. *Zygospira modesta* Hall (2008) Cynthiana, northern Garrard County, Kentucky.

PLATE V



Fossils of the Cynthiana Limestone—Ordovician

Explanation of Plate VI

(Cynthiana)

Figure

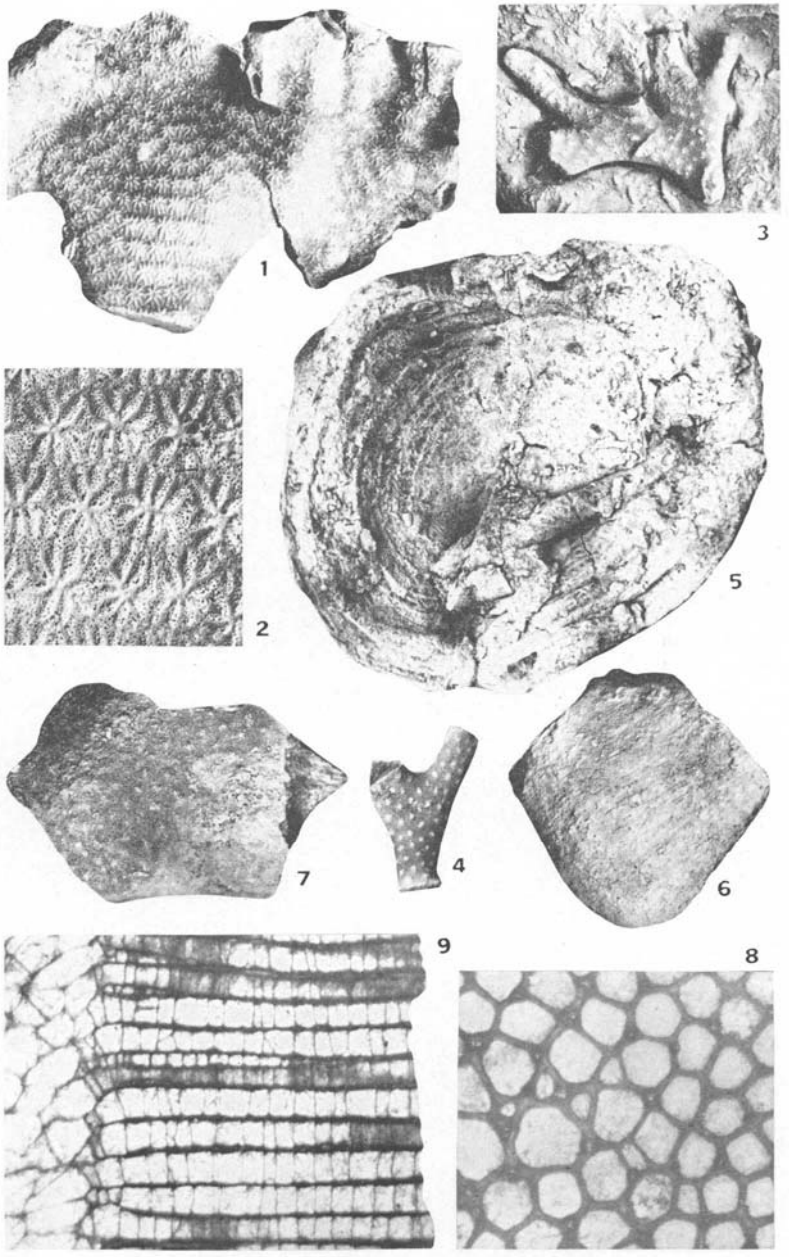
1- 2. *Constellaria florida* Ulrich (475) Cynthiana. Colby Station C. and O. RR., Clark Co., Ky. Fig. 2, X 3. (See X, 1).

3- 4. *Constellaria fischeri* Ulrich (1994) Cynthiana (Greendale), L. and E. RR. cut, Lexington. These specimens show the small size of the maculae but in the typical forms these are commonly not elevated and the species has a frondescent growth.

5. *Prasopora sp.* (1974) Basal Cynthiana, l½ miles south of Ambrose (Sulphur Well), Jessamine Co.

6- 9. *Dekayella milleri* sp. nov. (1997) Cynthiana, from small quarry just west of Muir Station, L. and N. RR., Fayette County, Ky. Fig. 6 shows the characteristic base. Fig. 9, X 20, fig. 8, X 30.

PLATE VI



Fossils of the Cynthiana Limestone—Ordovician

Explanation of Plate VII

(Cynthiana)

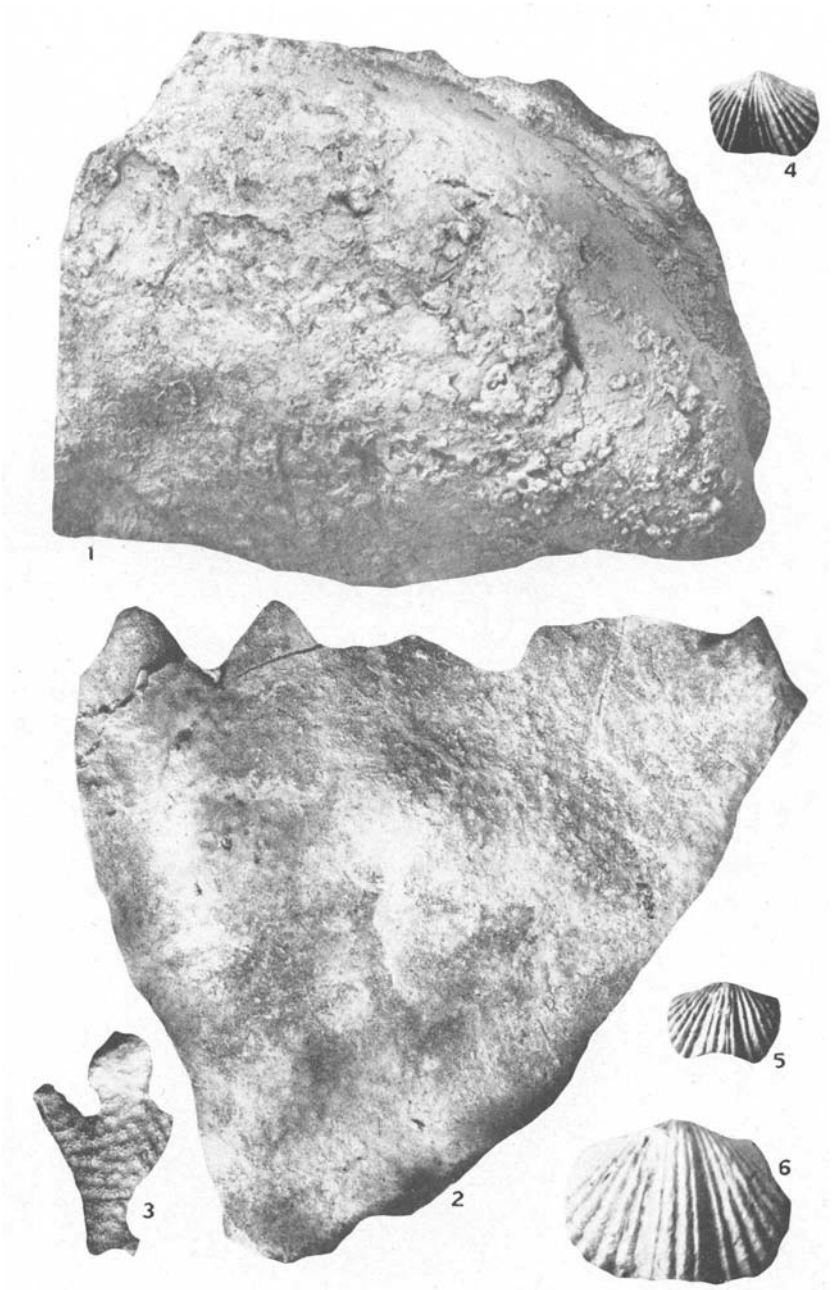
Figure

1. *Allonychia flanaganensis* Foerste. (1991) Cynthiana (Millersburg). Quarry five miles west of Winchester on Lexington road.
2. *Heterotrypa parvulipora* Ulrich and Bassler. (950) Cynthiana, L. and E. RR. cut near Lexington.
3. *Constellaria emaciata* (Ulrich and Bassler) (2002) Cynthiana, (Greendale) Southern RR. cut at Stone Road, about three miles south of Lexington.

4- 5. *Platystrophia colbiensis* Foerste. (2005) Cynthiana (Greendale). L. and E. RR. cut, Lexington, Kentucky. (See IV, 3, 4).

6. *Platystrophia colbiensis* var. *precursor* Foerste (2004) Cynthiana (Greendale), Colby Station, C. and O. RR,, west of Winchester, Clark County, Ky.

PLATE VII



Fossils of the Cynthiana Limestone—Ordovician

Explanation of Plate VIII

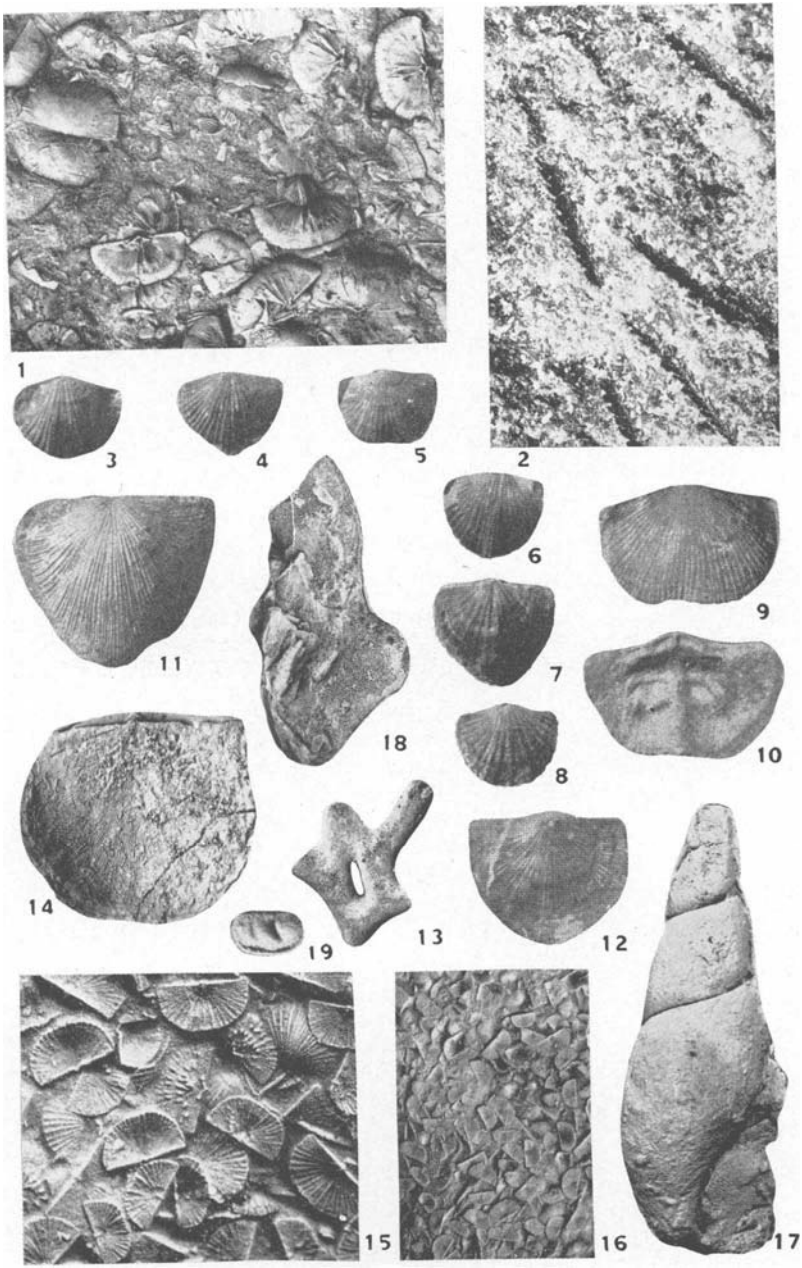
(Rogers Gap and Eden)

Figure

1. *Plectambonites rugosus* (Meek) (2027) Basal Million, one mile west of Hubble Lincoln County. (See XVI, 3, 4).
2. *Diplograptus sp.* (2030) Eden (Million) shale, two miles east of Brannon Station, Jessamine County. X 3.
3- 5. *Eridorthis nicklesi* Foerste After Foerste, Bul. Sci. Lab., Dennison Univ. Vol. XIV, PL IV, figs. 3a-b 1909.
6- 8. *Eridorthis rogersensis* Foerste After Foerste, ibid. figs. 4a, b.
9-10. *Clitambonites rogersensis* (Foerste) After Foerste, ibid. Pl. VIII, figs. 14a, b.
11-12. *Strophomena hallie* (Miller) After Foerste, ibid. Vol. XVII, 1912, Pl. II figs, la 1d.
13. *Eridotrypa aedilis* (Eichwald) (2034) Rogers Gap?, five miles east of Winchester on Mt. Sterling Road. (See II, 13-15).
14. *Rafinesquina winchesterensis* Foerste (2029) Cynthiana, nine miles east of Winchester on road to Mt. Sterling. (See V, 8, 9).
15-16. *Plectambonites plicatellus* (Ulrich) (Coll. Chas. L. Faber) Fulton bed. Union Bridge, Cincinnati, Ohio. Fig. 15, X 3.
17. *Fusispira sulcata* Ulrich (2028) Rogers Gap, five miles east of Winchester on road to Mt. Sterling.
18. *Hallopora onelli* var. *communis* (James) (2033) Basal Million, five miles east of Winchester on road to Mt. Sterling.
19. *Ctenobolbina ciliata* (Emmons) (2342) McMicken member of the Eden, Cincinnati, Ohio.

NOTE Through central Kentucky the appearance of *Plectambonites rugosus* in large numbers marks the base of the Million.

PLATE VIII



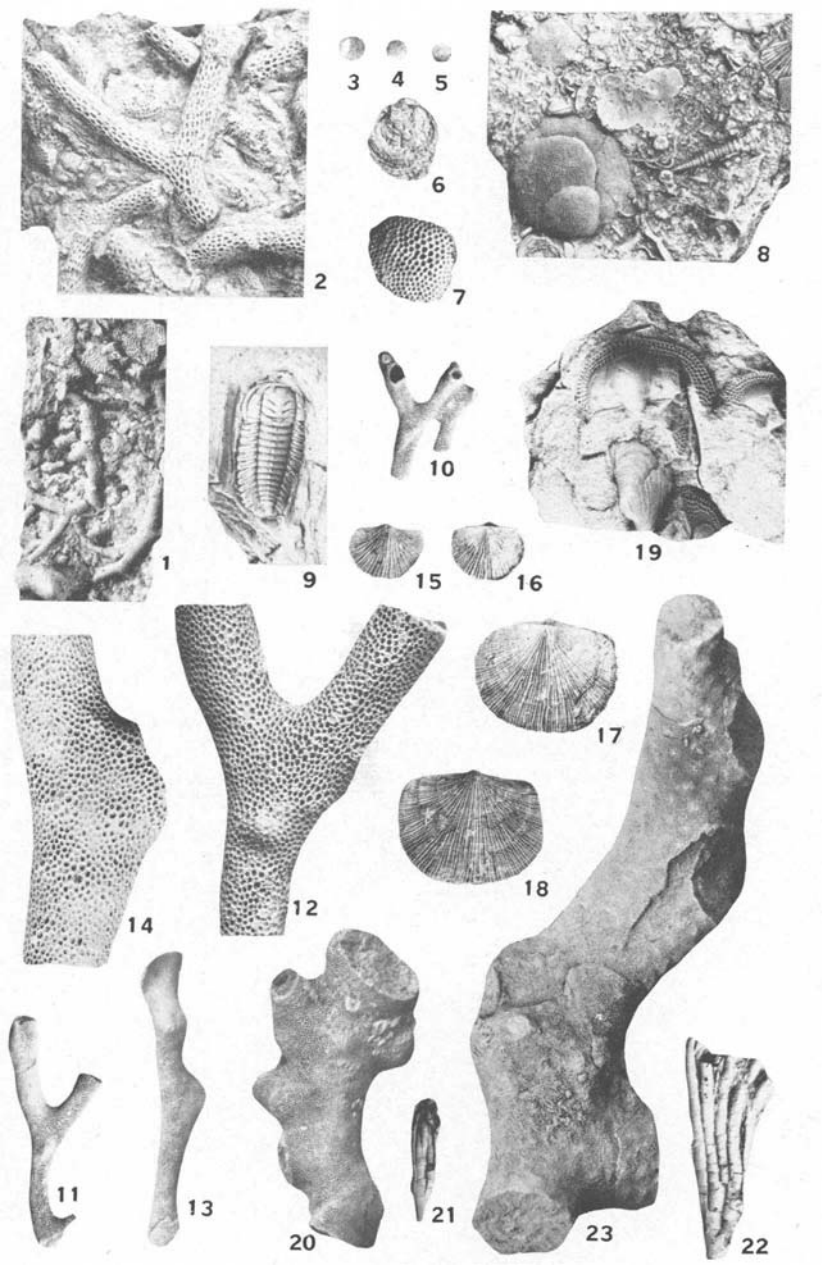
Fossils of the Rogers Gap and Eden—Ordovician

Explanation of Plate IX
(EDEN)

Figure

1- 2. *Bythopora arctipora* (Nicholson) (2360) Eden, Cincinnati, Ohio. Fig. 2, X 3.
3- 7. *Aspidopora eccentrica* (James) (2361) Southgate member of the Eden, Cincinnati, Ohio. Figs. 6, 7, X 3.
8. *Aspidopora newberryi* (Nicholson) (2362) Eden, Cincinnati, Ohio.
9. *Triarthus becki* Green. Southgate member of the Eden about 150 feet above low water. Rapid Run Creek, Cincinnati, Ohio. Collection Chas, L. Faber.
10-12. *Hallopora onealli* (James) (2363) Eden, Cincinnati, Ohio. Fig. 12, X 3.
13-14. *Hallopora onealli* var. *sigillaroides* (James) (2364) Eden, Cincinnati, Ohio.
15-18. *Dalmanella emacerata* (Hall) (2032) McMicken member of the Eden, Drennen Creek, Henry County, Ky.
19. *Cryptolithus tessalatus* Green (957e) This specimen is labeled "Upper Trenton," Cincinnati, Ohio.
20. *Batostoma jamesi* (Nicholson) (2230). Eden Cincinnati, Ohio.
21. *Ectenocrinus simplex* (Hall) (332c). Eden, Newport, Ky.
22. *Ectenocrinus grandis* (Meek) (1841). McMicken member of the Eden, Cincinnati, Ohio.
23. *Dekayella ulrichi* (Nicholson) (2031). McMicken member of the Eden, Drennen Creek, Henry County, Ky.

PLATE IX



Fossils of the Eden Shale—Ordovician

Explanation of Plate X

(Fairview)

Figure

1. *Constellaria florida* Ulrich (2012) Fairmount, one mile north of Hubble in northern edge of Lincoln County. (See VI, 1, 2).

2- 4. *Homotrypa cincinnatiensis* Bassler (2017) Fairmount, at Dix River bridge on Lancaster-Danville road via Hedgeville. Fig. 3, X 3, fig. 4 tangential section X 30.

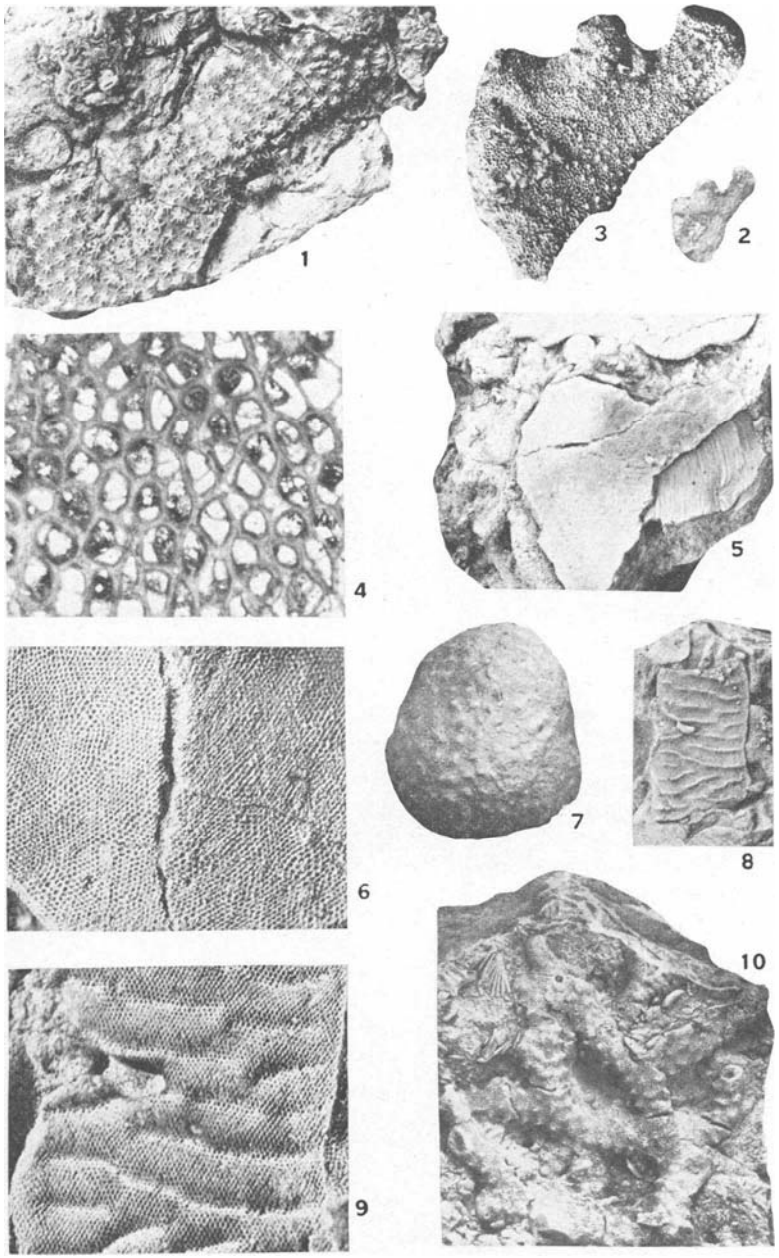
5- 6. *Escharopora pavonia* (D'Orbigny) (2369). Cincinnati, Ohio. Fig. 6, X 3.

7. *Monticulipora mamulata* D'Orbigny (2022). Fairmount, quarry one and one half miles north of Lancaster on Lexington road. The specimen is much smaller than normal.

8- 9. *Escharopora hilli* (James) (2025) Fairmount, quarry two miles north of Lancaster on Lexington road.

10. *Hallopora dalei* (M-E and H) (2026) Fairmount one mile north of Hubble in northern edge of Lincoln County.

PLATE X



Fossils of the Fairview—Ordovician

Explanation of Plate XI

(FAIRVIEW)

Figure

1- 2. *Platystrophia laticosta* Meek, after Foerste, Bul. Sci. Lab. Dennison Univ., Vol. XVI, 1910, Pl. III, figs, la, b. Fairmount, Cincinnati, Ohio.

3- 4. *Plectorthis plicatella* Hall, after Foerste, Bul. Sci. Lab. Denn. Univ., Vol. XVI, Pl. VI, figs. 5a, b. Fairmount, Cincinnati, Ohio. From Gurley Collection, Univ. of Chicago 8127.

5. *Plectorthis fissicosta* Hall ibid. Pl. VI, fig. 4, Fairmount, Cincinnati, Ohio. Gurley Coll., Univ. of Chicago 8127.

6- 7. *Strophomena planoconvexa* Hall (1884a) Base of Fairmount, Cincinnati, Ohio.

8- 9. *Strophomena maysvillensis* Foerste (2015), lower Fairmount. two and one half miles S-SE of Burdett Knob, Garrard County, Ky.

10. *Strophomena sinuata* James (1890a) Fairmount Cincinnati, Ohio.

11-12. *Plectorthis neglecta* James, after Foerste Bul. Sci. Lab. Dennison Univ., Vol. XVI 1910, Pl. VI, figs. 1d. e. Mt. Hope, Cincinnati, Ohio. James Coll., Univ. of Chicago, 2399.

13. *Orthorhynchula linneyi* (James) Fairmount 9½ miles SE of Lancaster on Cartersville road, Garrard County, Ky. (See IV, 11).

14. *Amplexopora septosa* (Ulrich) (2374) Fairmount, Cincinnati, Ohio.

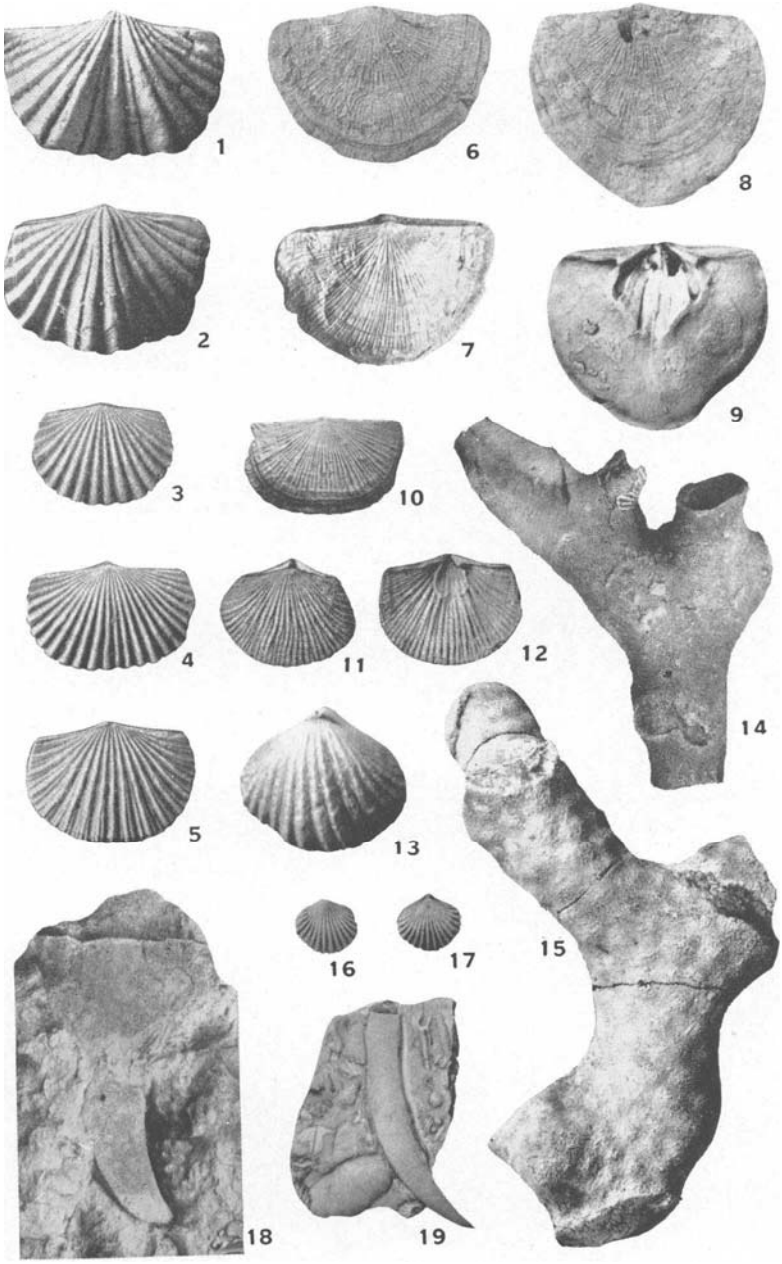
15. *Dekayia aspera* M-E and H. (2368) Fairmount, Cincinnati, Ohio.

16-17. *Plectorthis sordida* (Hall) (557) Cincinnati, Ohio.

18. *Escharopora maculta* (Ulrich) (2370) Fairmount, Cincinnati, Ohio. (See V, 10, 11).

19. *Escharopora falciformis* (Nicholson) (543a) Fairmount, Cincinnati, Ohio.

PLATE XI



Fossils of the Fairview—Ordovician

Explanation of Plate XII

(McMillan)

Figure

1- 2. *Chiloporella flabellala* (Ulrich) (2394). Corryville, Cincinnati, Ohio. Fig. 2, X 3.

3. *Platystrophia ponderosa* Foerste (1943) Oregonia member of the Arnheim formation near Preachersville, Lincoln Co., Ky. (See XIV, 15).

4. *Rafinesquina alternata* var. *ponderosa* Ulrich (1961) Cincinnati, Ohio.

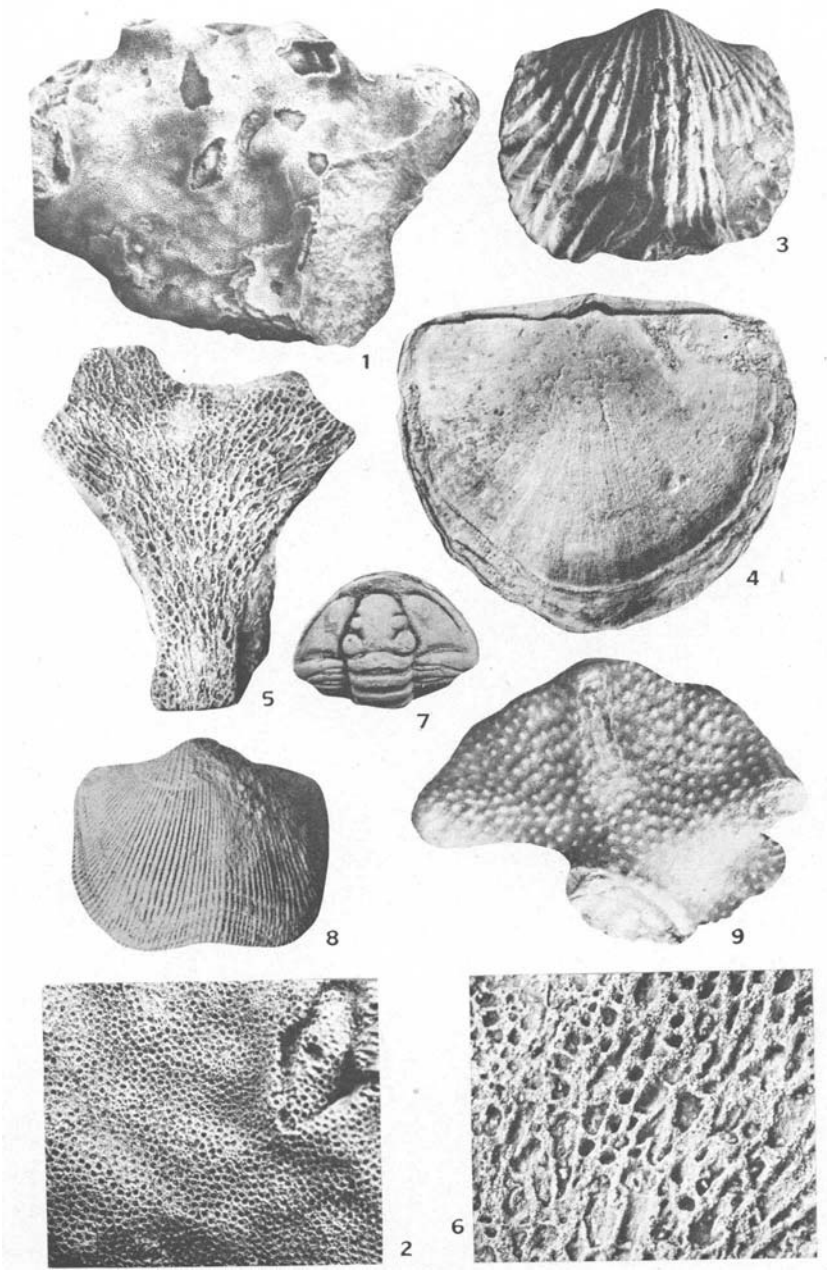
5- 6. *Heterospongia subramosa* Ulrich (1972) Mt. Auburn from near Hubble, northern Lincoln County. Fig. 6, a portion of Fig. 5, X 3.

7. *Calymene meeki* Foerste (955) Maysville, Cincinnati, Ohio.

8. *Hebertella sinuata* Hall (1964). Bellevue, Madison, Indiana.

9. *Monticulipora molesta* Nicholson, (2393) Bellevue, from region east of Cincinnati, Ohio.

PLATE XII



Fossils of the McMillan—Ordovician

Explanation of Plate XIII

(McMillan)

Figure

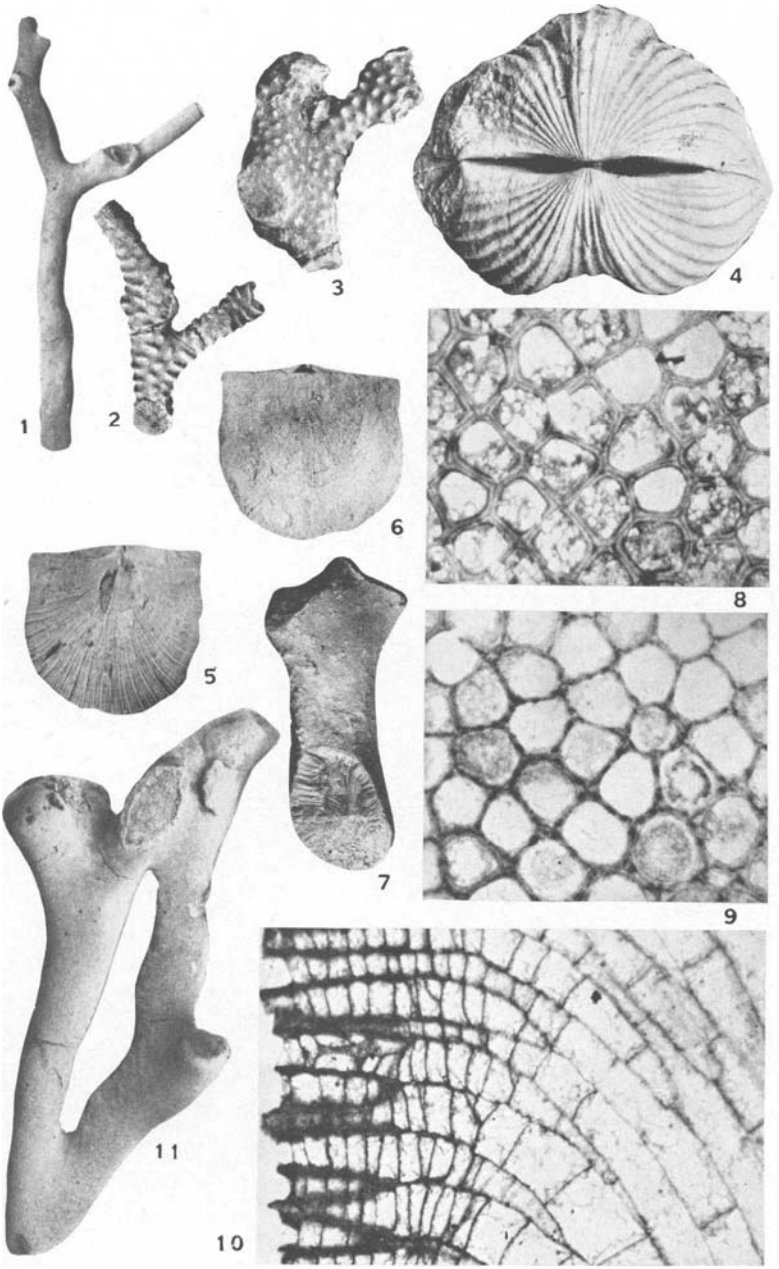
1. *Bythopora gracilis* (Nicholson) (2373) From vicinity of Cincinnati, Ohio.
2. *Hallopora rugosa* (M-E and H) (1962) Cincinnati, Ohio.
3. *Hallopora ramosa* (D'Orbigny) (1963) Cincinnati, Ohio.
4. *Platystrophia ponderosa* var. *auburnensis* Foerste (1965) Mt. Auburn, Cincinnati, Ohio.

5- 6. *Rafinesquina alternata* var. *fracta* (Meek) Coll. Chas. L. Faber. Bellevue from top of Frenchman's quarry, Cincinnati, Ohio.

7-10. *Amplexopora robusta* Ulrich (1968) Mt. Auburn from between Stanford and Preachersville, Lincoln County. Figs. 8, 9 tangential sections X 30, fig. 10 longitudinal section X 20. Fig. 9 (1967) is a tangential section not quite as deep as in fig. 8 showing the development of numerous small acanthopores. It is from a specimen from the same horizon one half mile N. W. of Gilberts Creek in the northern edge of Lincoln County.

11. *Hallopora andrewsi* (Nicholson) (2366) Cincinnati, Ohio.

PLATE XIII



Fossils of the McMillan—Ordovician

Explanation of Plate XIV

(Richmond)

Figure

1- 3. *Leptaena richmondensis precursor* Foerste. Figs. 1, 3 (1941) Upper Arnheim, Little Kentucky River, two miles north of Jericho, Henry County. Fig. 2 (1939) Oregonia member of the Arnheim, three miles west of Lebanon, Marion County, Kentucky.

4. *Platystrophia clarksvillensis* Foerste (1946) Oregonia member of Arnheim, RR. cut three miles west of Lebanon, Marion County, Kentucky.

5- 7. *Platystrophia clarksvillensis* Foerste (1945) Oregonia member of Arnheim formation one mile southwest of Stanford, Lincoln County, Ky.

8 *Heterospongia knotti* Ulrich (1937) Arnheim, Burdett Knob, Garrard County, Ky.

9-10. *Rhynchotrema dentatum* var. *arnheimense* Foerste Fig. 9 (1949) Arnheim formation, Little Kentucky River, two miles north of Jericho, Henry County,, Ky. Fig. 10 (1948) Oregonia member of Arnheim formation, six miles southeast of Lancaster, Ky.

11-12. *Zygospira kentuckiensis* James (2037) Waynesville, Eastwood, Jefferson County Ky.

13. *Heterospongia subramosa* Ulrich (1940) Oregonia member of the Arnheim, near Hubble. northern Lincoln Co., Ky. (See XII, 5,6).

14. *Cyphotrypa clarksvillensis* Ulrich (1953) Upper Arnheim, exposures along Rolling Fork, one mile N. E. of Bradfordville, Marion County, Ky. (See XV, 6).

15. *Platystrophia ponderosa* Foerste (1943) Oregonia member of the Arnheim, near Preachersville. Lincoln County, Ky. (See XII, 3).

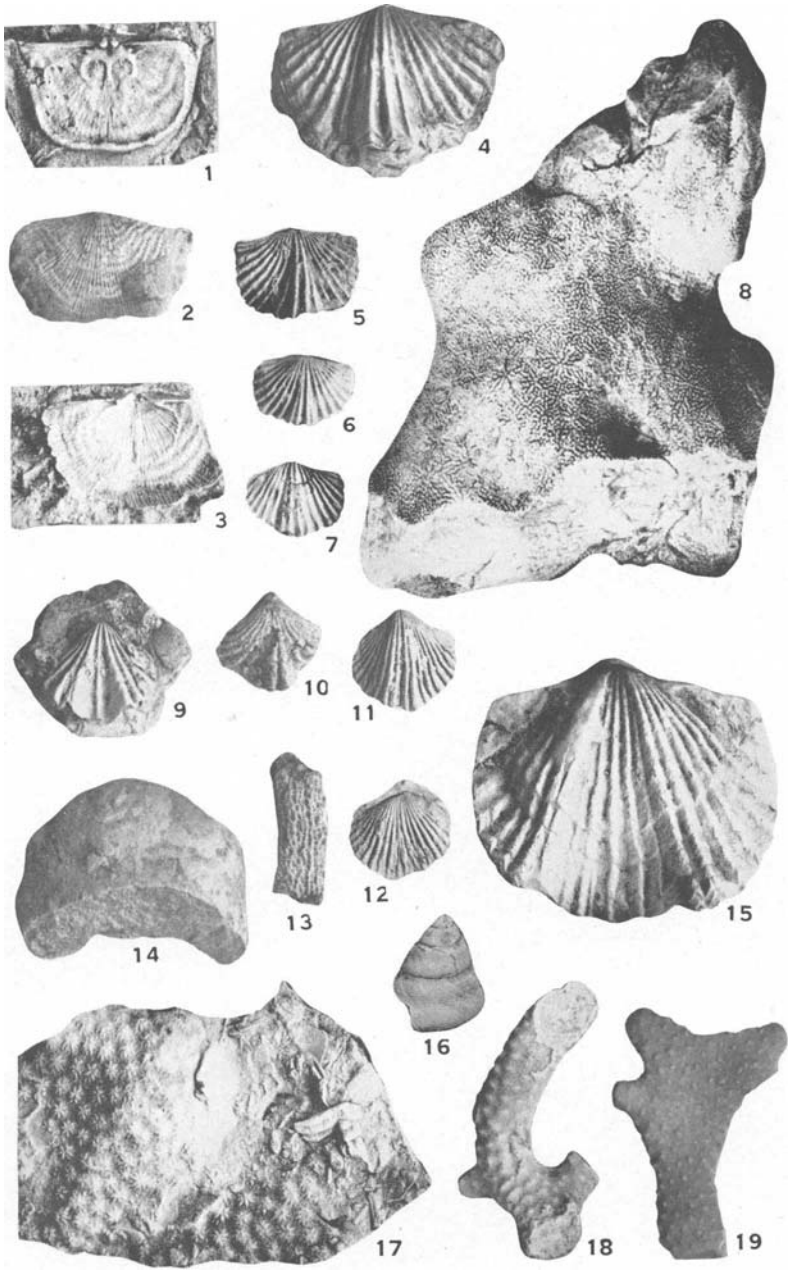
16. *Cyclonema bilix fluctuatum* (James) (1855) Waynesville, Weisberg, Indiana.

17. *Constellaria polystomella* Nicholson (1950) Upper Arnheim (C. polystomella zone), one mile north of Boston, Jefferson Co., Ky.

18. *Homotrypa wortheni* (James) (1955) Oregonia member of the Arnheim formation, three miles west of St. Mary along Prather Creek, Marion Co., Ky.

19. *Homotrypa bassleri* Nickles (1954) Upper Arnheim (C. polystomella zone), one mile north of Boston, Jefferson Co., Ky.

PLATE XIV



Fossils of the Richmond—Ordovician

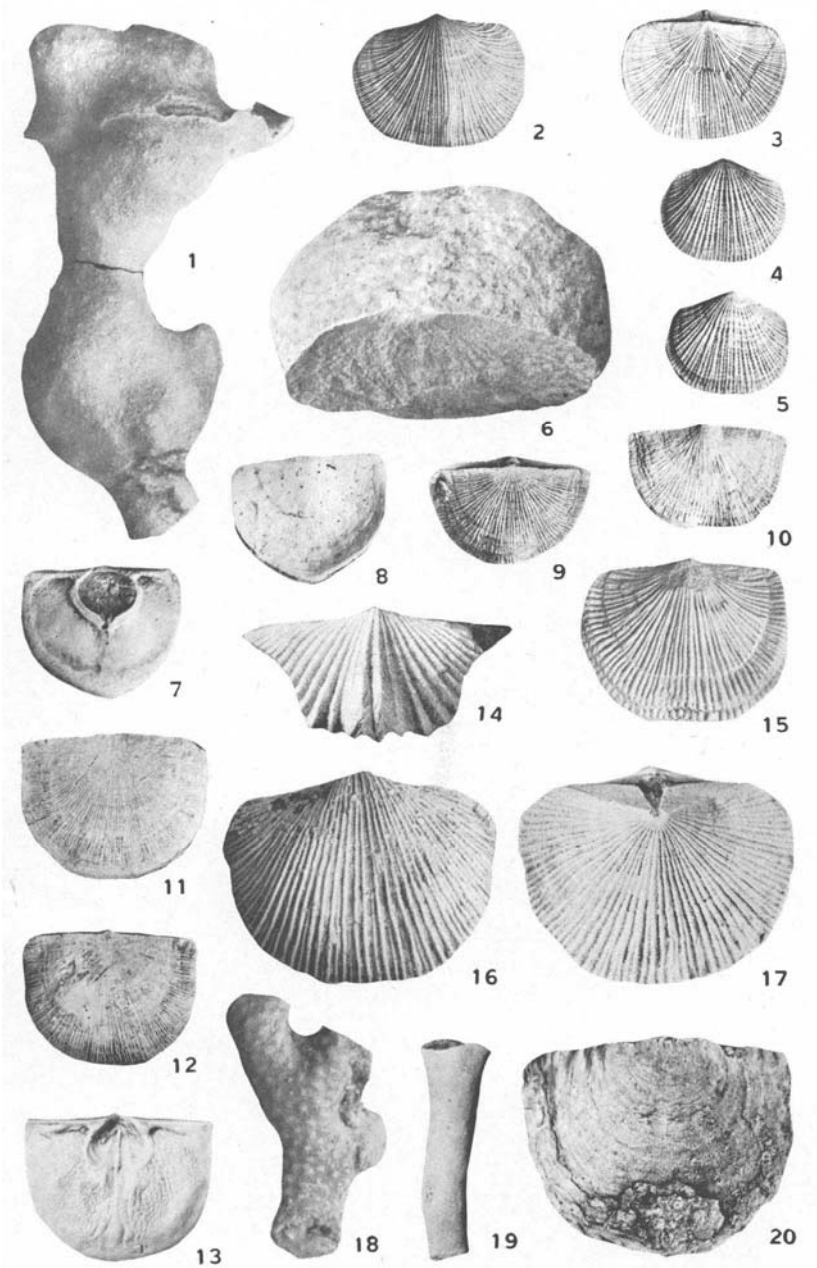
Explanation of Plate XV

(Richmond)

Figure

1. *Stigmatella dychei* (James) (2367) from vicinity of Cincinnati, Ohio.
2- 3. *Dalmanella meeki* (Miller) (2391) Waynesville, near Oxford, Ohio.
4- 5. *Hebertella insculpta* (Hall) (535) Butler County, Ohio.
6. *Cyphotrypa clarksvillensis* Ulrich (2035) Waynesville, Eastwood, Jefferson County, Ky. (See XIV, 14).
7- 8. *Strophomena nutans* (Meek) (2392) Waynesville formation, Jacksonburg, Ohio.
9-10. *Strophomena sulcata* (Verneuil) (2390) Whitewater formation, southern Ohio.
11-13. *Strophomena planumbona* (Hall) Figs. 11, 12 (567) Butler County, Ohio. Fig. 13 (2045) Liberty, Eastwood, Jefferson County, Ky.
14. *Platystrophia cypha* James, after Foerste, Bul. Sci. Lab. Dennison Univ. Vol. XVI, 1910, Pl. IV, fig. l0a. Specimen from Warren County, Ohio. James Coll., Univ. of Chicago 2326 (one of the types).
15. *Dinorthis subquadrata* (Hall) (2047) Liberty, Eastwood, Jefferson County Ky.
16-17. *Dinorthis carleyi* (Hall) (512) Madison, Indiana.
18. *Hallopora subnodosa* (Ulrich) (2372) Whitewater, southern Ohio.
19. *Bythopora meeki* (James) (2371) Waynesville, Oxford, Ohio.
20. *Strophomena vetusta* (James) (2375) Whitewater, Oxford, Ohio.

PLATE XV



Fossils of the Richmond—Ordovician

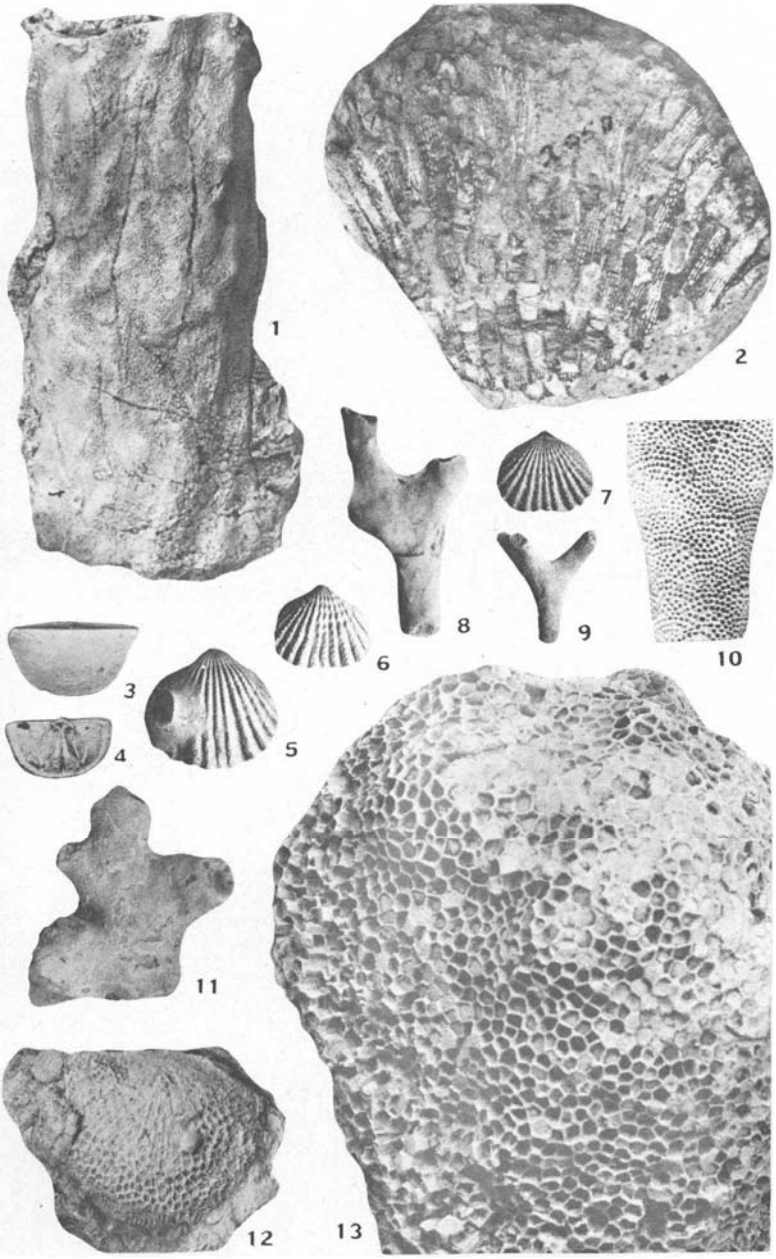
Explanation of Plate XVI

(Richmond)

Figure

1. *Beatricia nodulifera* var. *intermedia* Foerste (2051) A variety intermediate between the typical *B. undulata* and *B. nodulifera*. Liberty, Eastwood, Jefferson County, Ky.
2. *Calapoecia cribriformis* (Nicholson) (2050) Liberty, Eastwood, Jefferson County.
3- 4. *Plectambonites rugosus* (Meek) (2395) Liberty, Four Mile Creek, Creek near Oxford, Ohio. (See VIII, 1).
5- 7. *Rhynchotrema capax* (Conrad) (2041) Liberty, Eastwood, Jefferson County.
8. *Homotrypa austini* Bassler (2040) Liberty, Eastwood Jefferson County.
9-10. *Rhombotrypa subquadrata* (Ulrich) (2039) Waynesville, Oxford, Ohio.
11. *Rhombotrypa quadrata* (Rominger) (2046) Liberty, Eastwood, Jefferson County, Ky.
12. *Protarea richmondensis* Foerste (2044) Liberty, Eastwood, Jefferson County, Ky.
13. *Columnaria alveolata* (2094) X 0.6 Basal Liberty, Eastwood, Jefferson County, Ky. (See IV, 6).

PLATE XVI



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BIBLIOGRAPHY AND TEXT REFERENCES

Austin, G. M., 1927. *Richmond Faunal Zones in Warren and Clinton Counties, Ohio:* Proc. U. S. Nat. Mus. vol. 70, pp, 1-18.

Bassler, R. S.[15] 1903. *The structural features of the Bryozoan genus Homotrypa:* U. S. Nat. Mus., Proc., vol. 26, pp. 565-591.

1906. *A study of the James types of Ordovician and Silurian Bryozoa:* U. S. Nat. Mus. Proc., vol. 30, pp. 1-66.

1911. *The early Paleozoic Bryozoa of the Baltic province*: U. S. Nat. Mus., Bull. No. 77, 382 pp. 13 pls.

1915. *Bibliographic Index of North American Ordovician and Silurian fossils:* U. S. Nat. Mus., Bull. 92. two vols.

Beecher, C. E., 1889. *Brachiospongidae; a memoir on a group of Silurian sponges:* Yale Univ., Peabody Mus., Mem. 2, Pt. I, 28 pp.

Bucher, W. H., 1925. *Geology of Jeptha Knob*: Kentucky Geol. Survey. Series VI, vol. 21, pp. 193-237.

Butts, Charles,, 1915. *Geology of Jefferson County* (*Kentucky*): Kentucky Geol. Survey, Ser. 4. vol. 3, pt. 2, pp. 1-270, 65 plates.

Campbell, M. R., 1898. Richmond folio, Kentucky. U. S. Geol. Surv., Geol. Atlas, folio No. 46.

Clarke, John M., 1897. *Cephalopoda of Minnesota:* Minnesota Geol. and Nat. Hist. Survey, Paleontology, vol. 3, pt. 2, pp. 694-759.

1897a. *The Lower Silurian Trilobites of Minnesota:* Minnesota Geol. Nat. Hist. Survey, Paleontology, vol. 3, pt. 2, pp. 695-759.

Cumings, E. R., 1901. *Notes on the Ordovician rocks of southern Indiana:* Indiana Acad. Sci., Proc. for 1900, pp. 200-215.

1901b. *A section of the upper Ordovician at Vevay, Indiana:* Am. Geol., vol. 28, pp. 361-380.

1902. *A revision of the Bryozoan genera Dekayia, Dekayella and Heterotrypa of the Cincinnati group:* Am. Geol., vol. 29, pp. 197-218.

1903. *The morphogenesis of Platystrophia: A study of the evolution of a Paleozoic Brachiopod:* Am. Jour. Sci., 4th ser., vol. 15, pp. pp. 1-48, 121-136, 27 figures.

1908. *Stratigraphy and Paleontology of the Cincinnati Series of Indiana:* 32d. Indiana Report, pp. 607-1189.

1913. (And Galloway, J. J.) *The stratigraphy and paleontology of the Tanner's Creek section of the Cincinnati series of Indiana* 37th Indiana Report, pp. 353-479.

1922, Nomenclature and Description of the Geological Formations of Indiana. Handbook of Indiana Geology, State Department of Conservation, Pt. IV, pp. 403-570.

Fenneman, N. M., 1916. *Geology of Cincinnati and vicinity:* Ohio Geol. Survey, 4th ser., Bull. 19, 207 pp.

Foerste, A. F. 1902. *The Cincinnati anticline in Southern Kentucky:* Am. Geol., vol. 30, pp. 359-369.

1903. *The Cincinnati group in Western Tennessee between the Tennessee River and the Central Basin:* Jour. Geol., vol. 11, pp. 29-45.

1903b. *The Richmond group on the western side of the Cincinnati anticline in Indiana and Kentucky:* Am. Geol., vol. 31, pp. 33-361.

1904a. *Variation in thickness of the subdivisions of the Ordovician of Indiana:* Am. Geol., vol. 34, pp. 87-102.

1905. *The classification of the Ordovician rocks of Ohio and Indiana:* Science, N. S., vol. 22, pp. 149-152.

1905a. *Notes on the distribution of the Brachiopoda in the Arnheim and Waynesville beds:* Am. Geol.., vol. 36, pp. 244-250.

1906. *The Silurian, Devonian and Irvine formations of east-central Kentucky, with an account of their clays and limestones:* Kentucky Geol. Survey, Bull. No. 7, 369 pp.

1909a. *Preliminary notes on Cincinnatian fossils:* Dennison Univ. Sci. Lab., Bull., vol. 14, pp. 208-232.

1909b. *The Brachiopoda of the Richmond group:* Science, N. S., vol. 29, p. 635.

1909c. *Preliminary notes on Cincinnatian and Lexington fossils:* Dennison University, Sci. Lab., Bull., vol. 14, pp. 289-334.

1910. *Preliminary notes on Cincinnatian and Lexington fossils of Ohio, Indiana, Kentucky and Tennessee:* Dennison Univ. Sci. Lab., Bull., vol. 16, pp. 17-100 6 pis.

1912. *Strophomena and other fossils from Cincinnatian and Mohawkian horizons, chiefly in Ohio, Indiana and Kentucky.* Dennison Univ., Sci. Lab., Bull. vol. 17, pp. 17-172.

1912a. *The Arnheim formation within the areas traversed by the Cincinnati geoanticline:* Ohio Nat., vol. 12, pp. 429-456.

1913. *Chemical study of the Trenton and Stones River rocks in central Kentucky:* Kentucky Geol. Survey, series IV, vol. 1, pp. 387-439.

1914. *The Rogers Gap Fauna of Central Kentucky:* Jour. Cincinnati Soc. Nat. Hist., vol. 21, pp. 109-156.

1914a. *Lorraine Faunas of New York and Quebec:* Dennison Univ. Sci. Lab. Bull. 17, pp. 247-373,

1914b. *Notes\ on Agelacrinidae and Lepadocystinae, with descriptions of Thresherodiscus and Brockocystis:* Den. Univ. Sci. Lab. Bull., vol. 17, pp. 399-744.

1916a. *Notes on Cincinnatian fossil types:* Deninson Univ. Sci. Lab., Bull., vol. 18, pp. 285-355.

1917b. *Notes on Richmond and related fossils:* Jour. Cin. Soc. Nat. Hist., vol. 22, pp. 42-55.

Grabau, A. W., and Shimer, H. W., 1909. *North American Index Fossils:* A. G. Seller and Company.

Hall, James, 1847. *Paleontology of New York, vol.* 1. *Descriptions of the Organic Remains of the Lower Division of the New York System:*

1879. *Paleontology of New York,* vol. V, pts. 1 and 2. Ft. 1, 268 pp. 92 pls. Pt. 2, 492 pp., 113 pls.

1887. *Paleontology of New York,* vol. VI. Corals and Bryozoa. Text and plates; 298 pp., 66 plates.

1888. *Paleontology of New York,* vol. VII. Trilobites and other Crustacea. 236 pp., 36 pls.

1888a. *Paleontology of New York,* vol. V, pt. II, Supplement. Pteropoda, Cephalopoda and Annelida, pp. 1-42, pls. 114-129.

1894. *Paleontology of New York,* vol. VIII, pt. II, Brachiopoda. 394 pp., pls. 21-84. (Hall and Clarke).

Hayes, C. W., and Ulrich, E. O., 1903. Columbia Folio. U. S. Geol. Survey Folio 95.

James, J. F., 1886a. *Protozoa of the Cincinnati group:* Jour. Cin. Soc. Nat. Hist., vol. 9, pp. 244-252.

1891. *On the age of the Point Pleasant beds:* Jour. Cin. Soc. Nat. Hist., vol. 14, pp. 93-104.

1892. *Manual of the Paleontology of the Cincinnati group:* Jour. Cin. Soc. Nat. Hist., vol. 14, pp. 45-72; 149-163; vol. 15, pp. 88-100, 144-159.

1894. *Manual of the Paleontology of the Cincinnati group:* Jour. Cin. Soc. Nat. Hist., vol. 16, pp. 178-208.

1895. *Manual of the Paleontology of the Cincinnati group:* Jour. Cin. Soc. Nat. Hist., vol. 18, pp. 67-88.

1879. *The Paleontologist:* No. 4.

Jillson, W. R., 1929. *Geol. Map of Kentucky.* Ky. Geol. Survey, Series VI, Scale 1:500,000, colors.

McEwan, Mrs. Eula D., 1919. *A study of the Brachiopod genus Platystrophia:* U. S. Nat. Mus., Proc., vol. 56, pp. 383-448, pls. 42-52.

1920. *The Ordovician at Madison, Indiana:* Am. Jour. Sci., 4th Ser., vol. 50, pp. 154-158.

Matson, G. C., 1909. *Water resources of the Bluegrass region of Kentucky, with chapter on quality of the waters by Chase Palmer:* U. S. Geol. Survey, Water Supply Paper, No. 233, 223 pp., 3 pls., 6 figs.

Meek, F. B., and Worthen, A. H., 1866. Illinois Geol. Survey, vol. II, Paleontology, Introduction, pp. III-XIX.

1868. Illinois Geol. Survey, vol. III, Paleontology.

1873. Illinois Geol. Survey, vol. V, Paleontology.

1873a. *Description of invertebrate fossils of the Silurian and Devonian system:* Ohio Geol. Survey, vol. 1, pt. 2 (Paleontology), pp. 1-243.

Miller, A. M., 1905. *Lead and zinc-bearing rocks of central Kentucky, with notes on the mineral veins:* Kentucky Geol. Survey, Bulletin No. 2, 35 pp., 8 pls., 1 figure.

1913. *Geology of the Georgetown Quadrangle, Kentucky:* Kentucky Geol. Survey, 4th ser., vol. I, pp. 317-451.

1914. *Geology of Franklin County:* Kentucky Geol. Survey, ser. IV, vol. II, pt. III, pp. 7-89.

1915. *The Ordovician Cynthiana formation:* Am. Jour. Sci., 4th ser., vol. 40, pp. 651-657.

1919. *Geology of Kentucky:* Kentucky Dept. of Geol., and For., ser. 5, Bull. 2, 392 pp.

1925. *Geology of Woodford County:* Kentucky Geol. Survey, ser. VI, vol. XXI, pp. 119-144.

Miller, S. A. Various papers, chiefly in the Cincinnati Quarterly Journal of Science, and Journal of the Cincinnati Society of Natural History.

Nettleroth, Henry 1889. *Kentucky fossil shells:* A monograph of the fossil shells of the Silurian and Devonian rocks of Kentucky. Kentucky Geol. Survey, 245 pp., 36 pls.

Nicholson, H. A., 1875. *Description of the corals (and Bryozoa) of the Silurian and Devonian systems:* Ohio Geol. Survey, vol. II, pt. II, pp. 183-223, pls. XXI, XXII.

Nickles, J. M., 1902. *The geology of Cincinnati:* Jour. Cin. Soc. Nat. Hist., vol. 20, pp. 49-100, 1 pl. map.

1903. *The Richmond group in Ohio and Indiana and its subdivisions, with a note on the genus Strophomena and its type:* Am. Geol., vol., 32, pp. 202-218.

1905. *The upper Ordovician rocks of Kentucky and their Bryozoa:* Kentucky Geol. Survey, Bull. No. 5, pp. 1-64, 3 pls.

Orton, E.,, 1873. *Report on the Third Geological District; Geology of the Cincinnati Group; Hamilton. Clermont, Clark Cos:* Ohio Geol. Survey, Rp. I, pt. I, Geology, pp. 365-480.

Phalen, W. C., 1917. *Phosphate rocks of central Kentucky:* Kentucky Geol. Survey, 80 pp.; 19 pls. 2 maps.

Prosser, C. S., 1903. *Revised nomenclature of the Ohio geological formations:* Jour. Geol., vol. II, pp. 519-547.

1905. *Revised nomenclature of the Ohio geological formations:* Geol. Surv. Ohio 4th ser., Bull. No. 7, 36 pp.

Raymond, P. E. and Narraway, J. E., 1910. *Notes on Ordovician Trilobites; III, Asaphidae from the Lowville and Black River:* Carnegie Mus., An. 7, pp. 46-59.

Ruedemann, Rudolph, 1904. *Graptolites of New York:* pt. I. *Graptolites of the lower beds.* New York State Mus., Mem., No. 7, pp. 455-803, 17 pls.

1908. Graptolites of New York, pt. II, *Graptolites of the higher beds:* New York State Mus., Mem., No. 11, 583 pp., 31 pls.

Shaler, N. S. (1876). *On the fossil Brachiopoda of the Ohio Valley:* Publication of the Kentucky Geol. Surv., pp. 1-44, pls. 1-8.

Shideler, W. H., 1914. *The upper Richmond beds of the Cincinnati group:* Ohio Nat., vol. 14, pp. 229-235.

Ulrich, E. O., 1879a. *Descriptions of new genera and species of fossils from the Lower Silurian about Cincinnati:* Jour. Cincinnati Soc. Nat. Hist., vol. 2, pp. 8-30.

1882-1884. American Paleozoic Bryozoa. Jour. Cincinnati Soc. Nat. Hist., vol. 5, pp. 121-177, 232-259 (1882); vol. 6, pp. 82-92, 148-168, 245-279 (1883); vol. 7, pp. 24-51 (1884).

1888. *Correlation of the Lower Silurian horizons of Tennessee and part of the Ohio and Mississippi valleys with those of New York and Canada:* Am. Geol., vol. 1, pp. 100-110, 179-190, 305-315; vol. 2, pp. 39-44. (No further parts of this paper were published.)

1890. *New and little known American Paleozoic Ostracoda:* Jour. Cincinnati Soc. Nat. Hist., vol. 13, pp. 104-137, 173-211.

1890a. Paleontology of Illinois: Sponges, pp. 211-282, and Bryozoa, pp. 285-688. Illinois Geol. Survey, vol. 8, pp. 211-282 and 285-688.

1890b. *New Lamellibranchiata* (from the Lower Silurian): Am. Geol., vol. 5, pp. 270-284; vol. 6, pp. 173-181.

1892. *New Lamellibranchiata:* Am. Geol., vol. 10, pp. 96-104.

1892a. *New Lower Silurian Ostracoda,* No. 1: Am. Geol. vol. 10, pp. 263-270.

1892b. *New Lower Silurian Lamellibranchiata, chiefly from Minnesota rocks:* Minnesota Geol. and Nat. Hist. Survey, 19th Ann. Rept., pp. 211-248.

1893. *New and little known Lamellibranchiata, chiefly from the lower Silurian rocks of Ohio and adjacent states:* Ohio Geol. Survey, vol. 7, pp. 627-693, pls XLV-LVI.

1895. *On Lower Silurian Bryozoa of Minnesota:* Minnesota Geol. and Nat. Hist. Survey, final report, vol. 3, pt. 1 (Paleontology), pp. 96-332, 28 pls.

1897. *The Lower Silurian Lamellibranchiata of Minnesota,* (pp. 475-628); *The Lower Silurian Ostracoda of Minnesota* (pp. 629-693): Minnesota Geol. and Nat. Hist. Survey, final report, vol. 3, pt. 2 (paleontology), 13 pls.

1897a. (Ulrich and Scofield). *The Lower Silurian Gastropoda of Minnesota:* Minnesota Geol. and Nat. Hist. Survey, final report, vol. 3, pt. 2, (Paleontology), pp. 813-1081, 11 pls.

1897b. (And Winchell, See Winchell and Ulrich).

1897c. *Lower Silurian deposits of the Upper Mississippi: a correlation of the strata with those in the Cincinnati, Tennessee, New York and Canadian provinces and the stratigraphic and geologic distribution*

of the fossils: Minnesota Geol. and Nat. Hist. Survey, Paleontology, vol. 3, part 2, pp. 83-129.
1903. Columbia Folio (See Hayes and Ulrich).
1913. *Ordovician-Silurian boundary:* International Geol. Cong. Proc. at Toronto, pp. 593-667, 8 maps, 1 table.
1914. *The Ordovician-Silurian boundary:* Internat. Geol. Congress, XII, Canada, 1913, C. R. pp. 593-667. (Same paper as above, final publication).

Ulrich, E. O., and Bassler, R. S., 1904. *A revision of the Paleozoic Bryozoa, pt.* 1. *On genera and species of Ctenostomata:* Smithsonian Misc. Coll., vol. 45, pp. 256-294.
1904a. *A revision of the Paleozoic Bryozoa. Pt. II. On genera and species of Trepostomata* Smithsonian Misc. Coll. vol. 47, pp. 15-55.
1906. *New American Paleozoic Ostracoda. Notes and descriptions of upper Carboniferous genera and species:* U. S. Nat. Mus., Proc., vol. 30, pp. 149-164.
1908. *New American Paleozoic Ostracoda. Preliminary revision of the Beyrichidae, with descriptions of new genera:* U. S. Nat. Mus., Proc., vol. 35, pp. 277-340, pls.

Weller, Stuart, 1907. *The pre-Richmond unconformity in the Mississippi Valley:* Jour. Geol., vol. 15, pp. 519-525.
1902. *Paleozoic Faunas. New Jersey Geol. Survey,* Paleontology, vol. III.

Winchell, N. H., and Ulrich, E. O., 1897. *The Lower Silurian deposits of the Upper Mississippi: A correlation of the strata with those in the Cincinnati, Tennessee, New York and Canadian Provinces, and the stratigraphic and geographic distribution of the fossils:* Minnesota Geol. and Nat. Hist. Survey, Paleontology, vol. 3, pt. 2, pp. 83-129.

Winchell, N. H., and Schuchert, Charles, 1895. *Sponges, Graptolites, and corals from the Lower Silurian of Minnesota:* Minnesota Geol. and Nat. Hist. Survey, Final Rept., vol. 3, pt. 1 (Paleontology), pp. 55-95, 2 pls.
1895a. *The lower Silurian Brachiopoda of Minnesota:* Minnesota Geol. and Nat. Hist., Survey, Final Rept., vol. 3, pt. 1, (Paleontology), pp. 333-474, 6 pls.

Worthen, A. H., 1866-1890. Volumes 1 to 8 of the Geological Survey of Illinois.

Zittell, 1913. Textbook of Paleontology, vol. 1, Macmillan and Company.