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UPPER ORDOVICIAN FAUNAS OF ONTARIO AND QUEBEC

BY

A. F. FOERSTE

GEOLOGICAL SURVEY
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PREFACE

This volume is intended as a companion to Memoir 83.[1] Primarily, it is a study of fossils collected by the writer in southern Ontario, and Quebec, during the summer months of 1911 and 1912, but it describes also the other species known to exist in these areas. It includes, therefore, those species formerly described by Billings from the same area and horizon; those described eight years ago by the present writer;[2] and the new species of pelecypods described in 1920 by Beatrice Helen Stewart.[3]

Collections were made by the writer, in southern Ontario and Quebec, chiefly from strata corresponding in age to the Richmond formation of the Ohio-Indiana-Kentucky area. The collections, which were from the underlying Lorraine—corresponding to the Maysville and Eden formations of Cincinnatian areas—are, however, less complete. Only a few fossils from the Utica formation were collected, and they were not studied in sufficient detail to warrant their inclusion in this report.

The latter half of this report includes descriptions of all the definitely identified species from the Upper Ordovician strata of Ontario and Quebec, and of those species which, from their wide distribution in corresponding strata not far distant, probably occur also in Canadian areas. Finally, some species are figured that are difficult to distinguish from known Canadian forms.

Dr. Ray S. Bassler,[4] in 1915, published a full bibliography of the species described herein, and it is, therefore, unnecessary to cite any works except such as present the first description of the species, or which supplement the descriptions or figures in the present report.

The correlation tables of the strata discussed are based on those presented in Bassler's Index, but certain alterations have been made. For instance, the Richmond has been removed from the Silurian to the Upper Ordovician. The tables of formations in north-central New York and in Maryland have been transferred, and various names for Cincinnatian strata in Ontario have been added. For all these changes the writer alone is responsible.

The description of species is preceded by notes on their geographic distribution and stratigraphic range, with such conclusions as to their areas of origin, and the direction of their migrations in Middle and Upper Ordovician times, as appear to be warranted by the facts accumulated. These observations are based chiefly on the work of the great American pioneers of palæogeography, Dr. E. O. Ulrich, Prof. Charles Schuchert, and Dr. Ruedemann. Two publications by Dr. Ulrich[5] have been drawn upon freely, in many cases without direct citation. The writer is also indebted to Dr. Ulrich for numerous helpful notes, suggestions, and criticisms, only a small part of which are here specifically acknowledged.

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[1] "The Upper Ordovician Formations in Ontario and Quebec," Geol. Surv., Can., 1916.
[2] "Notes on the Lorraine Faunas of New York and the Province of Quebec," Bull. Sci. of Denison University.
[3] "Stratigraphy and Paleontology of Toronto and Vicinity," Twenty-ninth Annual Report, Ont. Dept. of Mines.
[4] "Bibliographic Index of American Ordovician and Silurian Fossils," published in 1915 by Dr. Ray S. Bassler, Bull. 92, U.S. Nat. Mus.
[5] "Revision of the Palæozoic Systems," 1910, Bull. Geol. Soc. Am.; "The Ordovician-Silurian Boundary," 1913, Compte Rendu Cong. Geol. Inter. xiie Sess.

The geological history of Canada is so bound up with that of North America as a whole, that it is impossible to understand some of the problems presented by Canadian geology unless they are considered as part of those presented by the entire continent.

The Upper Ordovician faunas of southern Ontario and Quebec are chiefly of southern origin, and entered from the Atlantic by way of the Gulf of Mexico embayment during some periods of deposition and, in other periods, by way of southeastern New York. Northward, these areas of deposition in southern Canada were cut off by the great mass of Archæan rocks. Frequent references to the Upper Ordovician strata of Ohio, Indiana, Kentucky, and New York are, therefore, inevitable.

E. J. Whittaker proved a most helpful assistant during two seasons of field work. The writer is greatly indebted to Dr. E. O. Ulrich for access to his collections, stored in the United States National Museum, and to his numerous notes and manuscripts, excerpts from some of which are included in this report. He is also much indebted to Dr. Rudolf Ruedemann for permission to examine the voluminous manuscript of his unpublished detailed report on the Lorraine strata of New York. The numerous collections gathered within the Victoria Memorial Museum at Ottawa by members of the Geological Survey and by private individuals were also freely used.

Upper Ordovician Faunas of Ontario and Quebec

PART I

UPPER ORDOVICIAN STRATA AND THEIR FAUNAS

EPICONTINENTAL SEAS

For many years it has been known that the marine strata exposed to the geologist are not those deposited in the abysmal depths, but those laid down in relatively shallow waters. If the term shallow be assumed to include depths not exceeding 100 fathoms, then shallow water deposits appear to have been frequent in the world's history, some spreading over wide areas. Most of the deposits now accessible could hardly have been deposited in waters deeper than 200 feet.

Whenever the margins of continents were depressed below sea-level, either locally or regionally, the sea penetrated these continental areas, in some cases producing embayments many hundreds of miles in length. These shallow waters are known as *epicontinental*, and have laid down most of the known marine strata.

During the Cambrian and Ozarkian the widest submergence took place—in each case near the close of the period—and this was followed by wide emergences that brought these periods to an end. This was not true, however, of the Canadian, Ordovician, Silurian, or Devonian.

These epicontinental seas invaded the land from various directions or even from several directions simultaneously. Penetration appears to have been frequent by way of Hudson bay;[1] the gulf of St. Lawrence and the embayment southwest of New York city; and the gulf of Mexico. Other lines of invasion, such as the one across Chesapeake bay, were used less frequently, at least during Ordovician time. Invasions from the Pacific took place chiefly across southern and lower California, and rarely reached the Mississippi valley, and probably never extended as far north-east as Ontario.

TERMINOLOGY OF UPPER ORDOVICIAN STRATA

USE OF TERM UPPER ORDOVICIAN

The term Upper Ordovician is here applied to the same strata as those described in Memoir 83. These were formerly known as the Hudson River, a designation no longer regarded as correct. Most of them are approximately equivalent in age to the Lorraine of New York, but the upper beds, including the Queenston shale, are younger than any part of the Lorraine.

[1] Ulrich, E. O., "The Ordovician-Silurian Boundary," Compte Rendu Cong. Geol. Inter., XIIe Session, Toronto, 1913.
Savage, T. E., and Van Tuyl, M., "Geology and Stratigraphy of the Area of Palæozoic Rocks in the Vicinity of Hudson and James Bays." Bull. Geol. Surv. Am., vol. 30, 1919, Fig. 1.

The term Upper Ordovician should—speaking strictly—include all Ordovician strata above the Trenton—namely, the Queenston, Lorraine, and Utica. In southern Ontario and Quebec the Utica is represented by the Collingwood and Gloucester members, which lithologically closely resemble the Utica shale of New York. The Collingwood shale is typically exposed along the southern shore of Georgian bay, but occurs also on Manitoulin island; east of Toronto; in the Ottawa basin; and thence eastward. The Collingwood basin of deposition was never connected directly with the Utica basin of New York, but contains a distinct fauna, probably corresponding in age to that of the lower part of the typical Utica of New York. In the Ottawa basin, the Collingwood is overlain by the Gloucester shale. According to Dr. Ruedemann, in his unpublished report on the Lorraine of New York, this shale contains a few of the fossils characteristic of the upper part of the typical Utica of New York, thus establishing the horizon of the Gloucester shale of Canada as upper Utica. Strata belonging to the Gloucester member of the Utica occur in southern Quebec as far east as Quebec city. Utica shales have long been known from the western margin of lake St. John, 120 miles northwest of Quebec. On the island of Anticosti, in the gulf of St. Lawrence, the Macastey black shale is evidently of Utica age.

Since the Richmond formation, including the Queenston shale, is here included in the Upper Ordovician, it follows that in southern Ontario the Upper Ordovician formations are directly overlain by the Cataract formation. From Niagara river to the vicinity of Duntroon, about 8 miles south of Collingwood, the base of the Cataract formation is the Whirlpool sandstone. This sandstone thins to the west and north, until in the western part of Ontario peninsula and on Manitoulin island Manitoulin dolomite forms the base. Eastward, the Whirlpool sandstone has not been traced as far as Rochester.

The upper part of the Cataract in southern Ontario is formed by two sandstone members, namely the Grimsby overlaid by the Thorold; of these the Grimsby is commonly reddish and contains *Lingula cuneata* Conrad, whereas the Thorold is grey and contains *Arthrophycus alleghaniensis* (Harlan).

No strata corresponding to the Cataract formation have been definitely recognized in the Ottawa basin, or in the southern part of Quebec. The highest Palæozoic strata in those areas belong to the Queenston member of the Upper Ordovician, with the exception of a small area of Devonian rock at Montreal. The writer heard reports of sandstone quarries on the west branch of Nicolet river, but failed to find them. If they exist they should belong to the upper part of the Cataract.

On Anticosti island, the Becsie River division of the Anticosti series may correspond in age with the Cataract, but the Gun River and Jupiter River divisions have been shown by Dr. E. O. Ulrich to be of Clinton age. All the strata between the Macastey shale and the Becsie River evidently belong to the Upper Ordovician, as here defined.

The Cataract formation corresponds to the Upper Medina sandstone of the older reports on Canadian geology, but when Grabau[1] proposed the term Queenston for the lower red clay shale section, he restricted the term

[1] Science, vol. 27, Apr. 17, 1908, p. 622.

Medina to its upper part, regarding the Queenston as an Upper Ordovician, and the restricted Medina as a Silurian formation.

Kindle[1] and Williams[2] have used the term in a similar way to include the sandstone beds between the Clinton formation above and the Queenston below. In 1915 Bassler[3] used the term in the old James Hall sense, modifying it to Medinan which made it include both Silurian and Ordovician formations as this boundary is drawn by the Canadian Geological Survey. Recently Cumings[4] has modified the use of Medinan as a series term and proposed to substitute it for Oswegan, thus making it include all the Silurian below the Clinton and excluding the Queenston shale.

USE OF TERM CINCINNATIAN

The term Upper Ordovician as here used is coextensive with the term Cincinnatian, as used by various writers on the geology of Ohio, Indiana, and Kentucky, the three states in which these Cincinnatian strata are typically exposed. The three major divisions of the Cincinnatian, as here defined, are, in descending order, the Richmond, Maysville, and Eden formations. The Utica might be added to these as a basal formation, but by Ulrich and Bassler it is placed in the basal part of the Eden.

In typical Cincinnatian areas these formations are further divided into rather numerous members, some of which have been subdivided, so that a complicated nomenclature has arisen, as will be seen from the accompanying table compiled from Bassler's Bibliographic Index.

One important difference should be noted. In the Index, the Richmond formation is placed in the basal part of the Silurian, whereas in the present report it is placed at the top of the Upper Ordovician.

The reference of the Richmond formation to the Silurian is advocated strongly and in considerable detail by Ulrich.[5] Dr. Ulrich recognizes in the Richmond the introduction of initial Silurian elements in an otherwise still prevailingly Ordovician fauna. Therefore, it represents to him the beginning of the Silurian era of deposition. Moreover, the beginning of the Richmond initiated one of the greatest diastrophic movements of the North American continent. At the close of the Maysville period of deposition, during Corryville and Mount Auburn times, almost the entire continent was above sea-level. However, even the lowest member of the Richmond—the Arnheim—covered considerable areas of Ohio, Indiana, Kentucky, and western Tennessee, and the succeeding divisions of the Fernvale and Waynesville covered areas of vast extent, representing several of the most extensive invasions of epicontinental seas which our continent has experienced, but now our studies include almost every part of the globe, and it is difficult owing to the numerous additional faunas, many of which are intermediate, to base the geology of other countries on these early-named divisions.

In the present report the writer has retained the Richmond in the upper part of the Ordovician, so as to secure conformity with the previous practice of the Geological Survey, Canada, and especially with Memoir 83. This procedure is based on the fact that, although Silurian elements

[1] Science, N.S., vol. 29, 1914, p. 918.
[2] Geol. Surv., Can., Mem. 111, p. 23, 1919.
[3] Bull. U.S. Nat. Mus., 92, vol. 2, pl. 3.
[4] "Handbook of Indiana Geology," p. 443, 1922.
[5] The Ordovician-Silurian Boundary, Twelfth Inter. Geol. Cong., 1913.

began to make their appearance in Richmond time, especially in faunas of northern and northeastern origin, the prevailing facies of these faunas in American areas still was Ordovician.

This introduction of Silurian elements while the American epicontinental faunas were still largely Ordovician may be due to the fact that Silurian faunas had come into existence contemporaneously in northwestern Europe, so that the Richmond strata of North America may actually have been contemporaneous with Silurian strata on the European continent. The routes by which these Silurian faunas entered the American epicontinental seas were not, however, well established until after Richmond time.

USE OF TERM QUEENSTON

Vanuxem, in 1840, introduced the term Medina sandstone to replace his term red sandstone of Oswego. Dr. Ulrich states[1] that in Vanuxem's district the deposits he called Medina comprise only Queenston strata, which there are overlaid by Oneida conglomerate (basal Clinton), full of *Arthrophycus*. This Oneida conglomerate rests directly on the red beds of the Queenston at Oswego Falls. The Queenston of New York and Pennsylvania is decidedly sandy. No satisfactory break can be found between the Queenston and the "White Medina." Vanuxem had no sandstone overlying the Medina in his area, but only the Oneida conglomerate, and, he, therefore, found it unnecessary to differentiate an upper sandstone facies, from a lower clay shale series. The term Medina had been given—as shown on page 3—various meanings by different authors. As used in this report, Medina sandstone includes the beds above the Queenston and below the Clinton.

Hall described, from the Medina of New York, a small fauna generally accepted as Silurian. Ulrich,[2] in 1890, described an ostracod under the name *Drepanella richardsoni canadensis*, stating that it "occurs at Oakville, Ontario, in purple shales, referred by the Canadian geologists to the Hudson River Group." There is no reference to the Medina, but geologists conversant with exposures at Oakville know that only the red clay shales, at present referred to the Queenston, are reddish or purplish in that area. Unfortunately it is not known exactly at what horizon in this Oakville shale the ostracod occurs, but, in the summer of 1911, the present writer and E. J. Whittaker of the Geological Survey, Canada, had the good fortune to find the same species, accompanied by other typical Richmond fossils, at several horizons near the middle of the Queenston section at several localities northwest of Meaford. Both at Oakville and at Meaford, the Queenston red clay shale is underlaid by grey, light green, or light blue somewhat calcareous strata containing a fauna suggesting an age corresponding to that of the Waynesville member of the Richmond formation. At Streetsville, west of Toronto, the Queenston shale rests on a rich coral zone which apparently contains traces of a Whitewater fauna. The *Drepanella canadensis* of the Queenston shale is most nearly related to *Drepanella richardsoni*, a form fairly common in the upper part of the Whitewater member of the Richmond formation in the area west of Wilmington, Ohio. Among other characteristic Queenston species were several ostracods which are either identical with, or closely allied

[1] Personal communication.
[2] Jour. Cincinnati Soc. Nat. Hist., 13, p. 118.

to, species known from the Saluda member of the Richmond in Indiana. From this it is inferred that the Queenston red clay shale is a lithologic, rather than a stratigraphic unit. At Oakville, for instance, it includes chiefly the Whitewater, but its basal part corresponds to the upper part of the Waynesville. At Streetsville, all of the Queenston shale belongs to the Whitewater. Here it is underlaid by fairly massive grey to bluish limestones interbedded with greenish clays, abundantly supplied with massive corals and a large growth of *Stromatocerium*, which also are of Whitewater age, but at a lower horizon.

USE OF TERM LORRAINE

In the final report of the Geological Survey of New York, 1842, Emmons adopted the following classification in descending order:

Grey sandstone (of Oswego)
Lorraine shales
Utica slate
Trenton limestone

The term Lorraine was intended to replace the term Pulaski, being more comprehensive than the latter. It was evidently intended to include all strata between the Oswego sandstone and Utica slate, which Vanuxem, in the Annual Report for 1840, had described under two separate formation names, in descending order Pulaski shales and Frankfort slate.

Stratigraphically, the Oswego probably corresponds in age to the upper or McMillan division of the Maysville formation in Cincinnatian areas, and the Pulaski to the lower or Fairview division. The Frankfort, in its typical exposures, represents only part of that portion of the Lorraine which may be correlated with the Eden formation. Dr. Ruedemann, in his unpublished report on the Lorraine of New York, divides the Pulaski into four members. The Indian Ladder beds of Schenectady basin, in the western part of Albany county, New York, are correlated with the middle or Southgate member of the Eden formation, and the Frankfort of the Trenton Falls basin is correlated with the Fulton, at the base of the Eden.

The term Lorraine, therefore, includes equivalents of the Eden formation of Cincinnatian areas, and of the lower or Fairview division of the Maysville formation, but not of the upper or McMillan division, with which the Oswego is provisionally correlated.

The Richmond formation is represented in the state of New York by the Queenston red clay shale, which outcrops along Niagara river, and along Oswego river, where both Oswego sandstone and Queenston red clay shale outcrop.

Vanuxem in his final report, in 1842, adopted the following terminology, in descending order:

Medina
Grey sandstone of Oswego
Hudson River group
  Pulaski
  Frankfort
Utica
Trenton

In this classification the term Hudson River is exactly equivalent to Lorraine, as proposed by Emmons, but it is entirely unsuitable as applied to strata between the Grey sandstone of Oswego and the Utica, because the Pulaski and Frankfort do not occur along Hudson river, the strata exposed there ranging from the Cambrian to the lower Trenton, with the Trenton predominating greatly.

USE OF TERMS HUDSON RIVER AND LORRAINE IN CANADIAN GEOLOGY

The true significance of the term Hudson River was not fully appreciated until Ruedemann in 1912 published his studies.[1] Then it became evident that three basins of deposition may be recognized in that part of New York crossed by this valley. In the eastern basin, along Hudson river, where the typical Hudson River formation is exposed, no strata above the lower Trenton have been recognized. In the middle or Schenectady basin, along Mohawk valley, extending westward from the vicinity of Hudson river, the great mass of shales all belong to the Trenton, with the exception of the beds called by Ruedemann the Indian Ladder shale. It is certain, however, that Vanuxem did not have the Indian Ladder shale in mind when he suggested the name Hudson River. It forms only an insignificant part of the shale sect on, and its fauna has become known only recently. Hence the term Hudson River is appropriate only for strata of Trenton or even earlier age.

The term Lorraine, on the contrary, is apparently applicable to that part of the Ordovician section in Ontario and Quebec which seems to correspond stratigraphically with the Lorraine section of New York. There is both a lithological and a faunal resemblance. Detailed palæontological studies may demonstrate that the Lorraine of Canada and the Lorraine of New York developed in quite distinct basins, resulting in distinct faunas, but stratigraphically they appear to be about the same age.

It is possible that some of the Lorraine-like strata in the vicinity of Toronto may prove strictly comparable with some of the typical Lorraine strata of New York, but some of the most characteristic fossils of the typical Lorraine have not yet been identified definitely from the Lorraine-like strata of the Toronto area, and sufficient faunal differences exist to warrant further investigation before intimate connexion between these basins of deposition is admitted.

The Lorraine-like strata in the Ottawa basin and in the province of Quebec were evidently deposited in a basin quite distinct from that of the typical Lorraine of New York. The Frontenac axis, extending from the Adirondacks to Georgian bay, separated the Canadian basins from the New York basin sufficiently to account for a distinct faunal development. It is probable, therefore, that, when the stratigraphy of the Ottawa and southern Quebec areas has been worked out, a series of distinct formation names will be found desirable.

[1] Ruedemann, R., "Lower Siluric Shales of the Mohawk Valley," Bull. New York State Mus. 162.

TERMINOLOGY OF UPPER ORDOVICIAN FORMATIONS ON MANITOULIN ISLAND AND OF GEORGIAN BAY

The following terminology is adopted in this report for the Upper Ordovician or Cincinnatian formations, as exposed in Manitoulin island and along the southern shore of Georgian bay, named in descending order:

Richmond formation
Kagawong member, of *Whitewater* and *Saluda* age
Meaford member, of *Waynesville* age
Maysville formation
Wekwemikongsing member
Eden formation
Sheguiandah member

The terms Kagawong, Wekwemikongsing, and Sheguiandah were proposed in an article[1] published in 1912. The term Meaford is proposed for the first time.

Only the upper part of the Sheguiandah formation is abundantly fossiliferous, and evidently is of Eden age. Its more precise correlation appears to be with the middle or Southgate member of the Eden as exposed in typical Cincinnatian sections in Ohio, Indiana, and Kentucky.

The lower part of the Sheguiandah formation, containing *Leptobolus insignis* and *Diplograptus* cf. *peosta*, may correspond to the Fulton shale, which is the representative of the Utica shale in typical Cincinnatian areas. At the very base of the Sheguiandah formation *Triarthrus eatoni* is present; this is regarded as a typical New York Utica species.

The Wekwemikongsing formation includes those Lorraine-like strata that lie directly above the Sheguiandah formation and beneath those strata of evident Richmond age: it is characterized by the early appearance of *Pholadomorpha pholadiformis*, associated with bryozoans identified by Dr. Ulrich as of Upper Fairmount or Bellevue age, thus indicating its Maysville age.

The Meaford formation includes those strata which contain a fauna suggesting their Waynesville age. At most localities on Manitoulin island the lowest recognizable fossils belong to the horizon characterized by the first appearance of *Hebertella insculpta*. Although this fossil is known here only from a few localities, the richly fossiliferous part of the Meaford formation usually begins at about the same relative level. Locally—for instance at Streetsville—fossiliferous horizons occur which appear to belong to distinctly lower horizons than the *Hebertella insculpta* horizon. These also are included in the Meaford formation. It is intended to include in the Meaford all those strata regarded as of Waynesville age, and not merely those above the *Hebertella insculpta* zone.

That part of the Meaford above the *Hebertella insculpta* horizon corresponds to the upper or Blanchester division of the Waynesville, and the part below this horizon is regarded as belonging to the middle or Clarksville division of the Waynesville. The lower or Fort Ancient division of the Waynesville is unknown in southern Ontario, unless a part of the underlying *Pholadomorpha* zone, here referred to the Maysville, belongs to this Fort Ancient member. The Kagawong member includes that part

[1] "The Ordovician Section in the Manitoulin Area of Lake Huron," Ohio Nat., Dec. 1912.

of the Richmond formation, as exposed on Manitoulin island, which lies directly above the Waynesville member.

In attempting to correlate the Kagawong with definite parts of the Richmond as exposed in Cincinnatian areas, the following facts must be considered. In the vicinity of Richmond, Indiana, the Waynesville member is overlaid by three members, giving the following section, in descending order:

Elkhorn member
Whitewater member
Liberty member
Waynesville member

The basal or Arnheim member is not exposed until a considerable distance south of Richmond, down Whitewater River valley.

Ninety-five miles southwest of Richmond, at Madison, on Ohio river, Charles Butts[1] identifies only the following members, also in descending order:

Saluda member
Liberty member
Waynesville member
Arnheim member

The problem is what has become of the Whitewater and Elkhorn members and where does the Saluda fit into the typical Richmond section? It appears that the typical Saluda may be traced northward to Versailles and Weisburg, Indiana, respectively 30 and 45 miles north and northeast of Madison, where strata containing Whitewater fossils occur not only beneath but above the Saluda. In other words, the Saluda appears there to fall entirely within the Whitewater. It is an arenaceous phase which during Whitewater time entered southeastern Indiana from the south or southwest. This arenaceous Saluda of southern Indiana carries a fauna sufficiently distinct from that of the typical Whitewater as seen farther north in Indiana to make it possible to speak of a Saluda fauna and of a Whitewater fauna, though in point of time the Saluda must be included in the Whitewater.

The Elkhorn and that part of the Whitewater which overlies the typical Saluda disappear before reaching Cooper Falls, a few miles south of Versailles. That part of the Whitewater which underlies the typical Saluda disappears before reaching Madison, so that the Saluda rests directly on the Liberty in that part of Kentucky which is west of the Cincinnati geanticline.

In studying the fauna collected from the Kagawong member on Manitoulin island it is noted that the most characteristic fossil of the Liberty, *Dinorthis subquadrata,* does not occur; moreover, the second most abundant fossil of the typical Liberty, the subquadrate form of *Strophomena planumbona,* also is absent, or at least has not been identified with certainty.

Ulrich, while examining the great coral zone at Streetsville, was impressed by the fact that, excepting the corals, the few bryozoans and other fossils found suggest a Whitewater, rather than a Liberty, age. The Liberty apparently is not represented on Manitoulin island, in the area south of Georgian bay, or in the Streetsville region.

[1] Kentucky Geol. Surv., ser. 4, vol. 3, pt. 2, Jefferson co., 1915, pl. 16.

On the other hand, some of the ostracods found in the middle and upper parts of the Kagawong member rather definitely indicate affinities with the Saluda member of the Richmond as exposed in southern Indiana. Such a reference, moreover, appears confirmed by the presence of numerous large specimens of *Columnaria, Calapoecia, Tetradium,* and *Stromatocerium,* with locally a fair number of well-characterized specimens of *Beatricea undulata.* On the other hand, some of the gastropods and pelecypods found in the Kagawong member suggest affinities with the Whitewater and this suggestion is strengthened by the presence of *Strophomena vetusta* and of *Ceraurinus marginatus* near the base of the Kagawong. Considering that the typical Saluda forms an horizon entering as a wedge into the typical Whitewater from the south, the fact that both Saluda and Whitewater forms occur in the Kagawong member is not anomalous.

In the Georgian Bay area, the Kagawong is represented by the Queenston shale. The prevailing colour of this shale is red, but most of its basal part is grey, green, or blue, and similar colours characterize the clays in the immediate vicinity of the thin, fossiliferous limestones that occur halfway up the red Queenston shale section. The ostracods occurring in these fossiliferous bands are in all probability of Saluda age.

The great coral zone that overlies that part of the Richmond formation which is definitely correlated with the Waynesville member at Streetsville, is placed provisionally, along with the overlying Queenston shale, in the Kagawong, for it is believed to carry a Whitewater fauna. It should be remembered, however, that the massive corals characteristic of this zone are known also in the Waynesville member in other areas. It is the associated bryozoans and other fossils which are supposed to be of Whitewater age.

TERMINOLOGY OF UPPER ORDOVICIAN FORMATIONS IN THE OTTAWA BASIN AND IN THE PROVINCE OF QUEBEC

Northeast of the Frontenac axis, during Eden and Maysville times, the faunas appear to have been sufficiently different from those south and southwest of the axis to require distinctive names; but the difference is not sufficient to warrant it without the aid of lithological contrasts. The following names are used here for the Upper Ordovician strata in the Ottawa basin and in the Quebec region.

- Richmond formation
  - *Queenston* member
  - Coral zone
  - Beds of *Waynesville* age
- Lorraine formation
- Utica formation
  - *Gloucester* shale
  - *Collingwood* shale

In the Ottawa basin and in southern Quebec, the red clay shale overlying the fossiliferous beds of the Richmond formation appears to correspond exactly to the typical Queenston shale in southern Ontario, and, like the Queenston, it rests directly on lower Richmond strata—apparently of Waynesville age. However, in the eastern areas fossils occur only in the basal layers of the Queenston and these belong to the same species as those occurring in the Waynesville strata immediately beneath. From analogy with the typical Queenston in southern Ontario, it is assumed that all the red clay shale except the basal layers belongs to strata overlying the Waynesville, presumably to strata approximately equivalent to the Whitewater member of the Richmond.

The richly fossiliferous part of the Richmond on Nicolet river, directly underlying the Queenston, is regarded as of the same age as the Waynesville member in Cincinnatian areas, and as the Meaford along Georgian bay and on Manitoulin island. At several horizons these beds contain *Strophomena hecuba* and at the lowest level at which fossils occur regarded as undoubtedly of Waynesville age, *Strophomena planumbona* and *Rhynchotrema perlamellosum* are found. Although *Strophomena* occurs only at intervals in the middle and lower part of the Waynesville strata, the Waynesville as a whole is regarded in this report as forming the *Strophomena* zone. On Nicolet river this zone has a thickness of 156 feet.

Those strata along the Nicolet River section, which lie below the lowest strata containing *Strophomena planumbona* and *Rhynchotrema perlamellosum*, and which contain *Pholadomorpha pholadiformis*, associated with *Cymatonota, Psiloconcha, Rhytimya,* and other pelecypods, apparently form a distinct faunal unit, and are here referred to as the *Pholadomorpha* zone. This is to be distinguished from the *Pholadomorpha* zone in the Richmond formation. Although the pelecypods are few, the species appear to be confined to horizons definitely below the *Strophomena planumbona* zone, and to that extent are diagnostic.

Beneath the *Pholadomorpha* zone, which, on Nicolet river, is 540 feet thick, occur those strata referred to in Memoir 83 as the *Proetus, Leptæna,* and *Cryptolithus* zones, 290 feet, 730 feet, and at least 800 feet thick, respectively.

The *Proetus* zone is correlated with the middle or Southgate member of the Eden formation in Cincinnatian areas. It also corresponds, apparently, with the upper part of the Sheguiandah formation of Manitoulin island and Georgian bay.

The *Leptæna* zone extends from the highest level containing *Cryptolithus* to the highest zone containing *Leptæna.* The absence of *Cryptolithus* and the presence of *Leptæna* are its distinctive features.

The basal limit of the *Cryptolithus* zone is not exposed and its total thickness is unknown. In the Nicolet River section, a species of *Triarthrus* related to *T. eatoni* is known only from an horizon about 100 feet below the highest horizon at which *Cryptolithus* has been found. However, at other localities, *Triarthrus* is not uncommon in strata containing both *Cryptolithus* and *Leptæna,* so that *Triarthrus* probably has a very much greater vertical range than is yet indicated by the Nicolet River area. The writer has never found the *Cryptolithus* zone in contact with any strata of Utica or Trenton age in Quebec and he is, therefore, influenced by the fact that in the Don valley *Leptæna* is associated with *Cryptolithus* in a zone above the Utica of that area, and still farther above the Trenton. At St. Catharines, northwest of Niagara Falls, the interval between the base of the Queenston red clay shale and the top of the Trenton is estimated at 868 feet. Estimating the Utica to be 200 feet thick the total thickness of the Lorraine and the fossiliferous part of the Waynesville member must be about 670 feet. Since the Utica outcrops near lake level at Whitby, east of Toronto, and the base of the Queenston is only slightly above railway level at Oakville, it is estimated that the Don Valley exposures must lie at least 200 feet, possibly over 300 feet, above the top of the Utica, and a considerable section, possibly much greater than 300 feet, may exist in southern Quebec between the lowest Nicolet River strata (the Hyacinthe) and the top of the Utica.

The *Triarthrus* of the *Cryptolithus* zone resembles *T. eatoni* rather than *T. becki*, and the *Cryptolithus* resembles *C. bellulus* rather than *C. tesselatus*, so that the writer is inclined to regard this zone member also as of Eden age. Dr. Ulrich[1] states that *Triarthrus* does not occur in the lower or Economy member of the Eden formation at Cincinnati, O., but in the Southgate member, at least 130 feet above the base of the Economy. On Rapid Run it occurs 180 feet above low water of the Ohio. It occurs in a corresponding position in the Lorraine gulf, in the lower part of the Lorraine section.[2]

Provisionally, therefore, the *Cryptolithus* zone may be referred to the Southgate member of the Eden, leaving considerable room beneath for other strata, some of which possibly may correspond to the Frankfort of New York.

In a similar manner, the strata exposed in Don valley probably belong at least as high as the Southgate member of the Eden. The presence of *Catazyga erratica* in the same layers as *Leptœna* presents no difficulties, for both of these fossils occur in the *Cryptolithus* zone of Nicolet river and at other localities in Quebec.

The few bryozoans determined by Bassler from Don valley are Eden and Maysville species, suggesting upper Eden age. Nothing as low as the Economy member of the Eden is indicated and the middle or Southgate member is apparently absent.

SOURCES AND MIGRATIONS OF VARIOUS UPPER ORDOVICIAN EPICONTINENTAL FAUNAS

FAUNAS OF SOUTHERN OR ATLANTIC ORIGIN

The Eden, Maysville, and Richmond faunas of southern Ontario and Quebec apparently are migrants from areas farther south. This is true especially of those faunas on Manitoulin island and Georgian bay, which find their nearest relatives in the typical Cincinnatian areas of Ohio, Indiana, and Kentucky.

Similar conditions prevail in the Toronto area, but Toronto is much nearer the typical Lorraine area of north-central New York, and appears to show distinct traces of migrants from this area also. In the Eden exposures in Don valley, for instance, bryozoans are more common than in the Ottawa and Quebec basins, and closely resemble species in the typical Eden areas of Ohio, Indiana, and Kentucky. Nevertheless, the associa-

[1] Personal communication.
[2] Ulrich, E. O., "Revision of the Palæozoic Systems," Bull. Geol. Soc. Am., 22, 1911, pp. 296, 297.

tion of *Leptæna* with *Cryptolithus* and *Catazyga erratica*, and the relative abundance of pelecypods, suggest affinities with the so-called Lorraine faunas of the Quebec areas, and the latter are regarded as related to, but not identical with, the Lorraine of New York. In a similar manner, the *Pholadomorpha* horizon of Humber river, in the Toronto area, contains bryozoans suggesting relationship with the middle Maysville formation of Cincinnatian areas, but the presence of *Ischyrodonta unionoides*, *Orthodesma nasutum*, *Pterinea demissa*, and *Catazyga erratica* suggest affinity also with the upper part of the Pulaski formation in New York. In fact, the Humber River area is the only one which at present seems to present possibilities of producing a typical upper Pulaski fauna.

In the Ottawa and Quebec basins the so-called Lorraine strata present scanty traces of bryozoans, and few of the forms are such as are plentiful in typical Cincinnatian areas. In fact, the faunas northeast of the Frontenac axis show much closer relationship to those of the Lorraine of New York, than to those of the typical Cincinnatian.

The Utica fauna is an Atlantic invasion,[1] and the Fulton shale at Cincinnati represents its farthest extension southwestward. The *Triarthrus* horizon of the Sheguiandah formation probably represents its greatest northwestward extension. The typical part of the Eden formation, however, and most of the Maysville formation, in typical Cincinnatian areas, represent, probably, an invasion by way of the gulf of Mexico,[2] although that part of the pelecypod fauna in the Bellevue member of the Maysville may represent an Atlantic invasion.

Most of the typical Richmond also appears to represent invasions via the gulf of Mexico,[3] although there may have been many subsidiary embayments, but the general origin was from the south. No Upper Ordovician formation contains a greater number of distinct faunules than the Richmond. The origin of some of these has not been traced. For instance, part of the Blanchester fauna in the Waynesville may have had a northwestern origin and some of the coral forms found in various parts of the Richmond may have had a northern origin. But the prevailing direction of migration appears to have been from the south.

The typical Lorraine of New York contains species which probably were derived by way of Cincinnatian areas. More than one-third, possibly more than one-half, of the Lorraine species of New York are found also at Cincinnati.

There is, however, a large element of the New York Lorraine fauna which is not represented in the Cincinnati area, and which includes numerous pelecypods. It has been derived, apparently, from some eastern source, the Lorraine embayment in New York having had direct connexion southeastward with the Atlantic. It is probable that the typical Lorraine of north-central New York, and the so-called Lorraine of southern Canada derived a considerable part of their faunas from the Atlantic, though not necessarily through the same embayment. The Ottawa and southern Quebec areas may have occupied basins distinct from that of the typical Lorraine of New York, and may have had a somewhat different faunal development.

[1] *See* Palæogeographic map III in "The Ordovician-Silurian Boundary," by E. O. Ulrich, in Compte Rendu Cong. Geol. Inter., XIIe, Sess., Toronto, 1913, pp. 662.
[2] Ibid. *See* maps III, IV, and V.
[3] Ibid. *See* map VI.

PRECAMBRIAN SHIELD

The well-known Precambrian shield of Canada has in the course of time received many bad dints, the two most severe being a southern axis of depression that includes Hudson and James bays, Fox channel, and the gulf of Boothia, and a northern axis that includes Davis strait, Baffin bay, and Smith sound. Along the southern axis lie Ordovician and Silurian rocks with Devonian at the southern end, but along the northern axis only Upper Cretaceous and Tertiary rocks are known. Faulting has, apparently, in large measure determined the deposition of all these rocks and the lines of faulting indicate that the Palæozoic formations extended at one time much farther southeast than at present, but have been removed by erosion, the present exposures being retained chiefly on sunken fault-blocks.

Hudson bay is a typical epicontinental sea. Its waters—like that of the average waters of the Canadian Arctic seas—are seldom more than 200 fathoms deep.

EDEN AND MAYSVILLE OUTCROPS ABSENT ON THE PRECAMBRIAN SHIELD

Black shales, apparently of Utica age, are known from the western margin of lake St. John, 120 miles north of the city of Quebec. At Port Burwell, at the northern end of Labrador, thick slabs of black limestone from some unknown locality occur loose on the beach and contain *Agygites canadensis* Chapman, a familiar Collingwood fossil. From south Baffin island Prof. Schuchert has identified a *Triarthrus* (probably *T. eatoni*) in strata regarded by him as Collingwood.

No representative of the Eden or Maysville has been found within the Precambrian shield, and their northern origin seems, therefore, impossible; and as no strata of those ages are known from the Mississippi valley or farther westward, their source appears to have been from the south and southeast, as already indicated.

ARCTIC INVASIONS DURING MOHAWK AND RICHMOND TIMES

A considerable part of the Richmond faunas may be regarded as a recurrence of Mohawk faunas, especially of the Black River and early Trenton. During both Richmond and Mohawk times marine waters appear to have invaded the United States as far south as Tennessee by way of Hudson bay. (*See* Palæogeographic maps I, II, VI, and VII, "The Ordovician-Silurian Boundary.") The northern Richmond (Shumattawa and Maquokata) invasion, apparently, swept round by way of Manitoba and the Maritime Provinces and did not reach any part of southern Ontario or southern Quebec, so that the typical Richmond, and the Eden and Maysville, of southern Canada, must have had a southern origin.

If the Richmond be regarded as a recurrent Black River fauna, the original distribution of this fauna during Black River time, and its probable area of retreat during Eden and Maysville times are matters of considerable importance.

MOHAWKIAN OUTCROPS ON THE PRECAMBRIAN SHIELD

Black River fossils at Port Burwell are listed by Prof. Schuchert[1] and include large species of *Plectoceras*, *Endoceras*, and *Cyclendoceras*. Both Schuchert and Whiteaves have identified fossils from Apatok island, 100 miles west of Port Burwell, and many of these are regarded by Bassler[2] as presenting a Richmondian facies. In the following list[3] the first four fossils were listed by both Whiteaves and Schuchert.

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

In the long list of Mohawkian species listed by Schuchert[4] from Sillimans Fossil mount, the following suggest Black River affinities:

Calapoecia canadensis Billings
Orthis tricenaria Conrad
Hebertella bellarugosa (Conrad)
Lophospira spironema Ulrich and Scofield
Liospira larvata (Salter)
Eurystomites plicatus Whiteaves
Bythocypris granti Ulrich

According to Bassler,[5] the geologic section on southern Baffin island consists of crystalline Archæan rocks, overlaid by Black River strata, followed by an early Trenton equivalent to the Stewartville and Prosser limestones of Minnesota, which, in turn, is succeeded unconformably by the widespread coral zone of the Richmond group.

The following species are listed from both the head of Frobisher bay, and from the Black River limestones on Nelson river, west of Hudson bay.[6]

Receptaculites cf. *oweni* Hall
Halysites gracilis (Hall)
Calapoecia canadensis Billings
Hebertella bellarugosa (Conrad)
Maclurina manitobensis (Whiteaves)
Endoceras proteiforme Hall
Cyrtoceras manitobense Whiteaves

The following forms listed from the head of Frobisher bay have affinities with species in the upper Mississippi valley and in Manitoba (Stony mountain and elsewhere) rather than with those of New York

[1] Am. Jour. Sci., 38, 1914, p. 468.
[2] "The Early Palæozoic Bryozoas of the Baltic Provinces," 1911, U. S. Nat. Mus., Bull. 77, p. 36.
[3] For the geographic location of some of the localities here mentioned *see* Palæogeographic map III "The Ordovician-Silurian Boundary." Compte Rendu Cong. Géol. Inter., XIIe Sess., 1913.
[4] Schuchert, C., "On the Lower Silurian (Trenton) Fauna of Baffin Land." Proc. U.S. Nat. Mus., vol. 22, 1900.
[5] Bassler, R. S., "The Early Palæozoic Bryozoa of the Baltic Provinces," U. S. Nat. Mus., Bull. 77, 1911, p. 36.
[6] Savage, T. E., and Van Tuyl, F. M., "Geology and Stratigraphy of the Area of Palæozoic Rocks in the Vicinity of Hudson and James Bays," Bull. Geol. Soc., Am., 30, 1919, pp. 347-348.

state and southern Canada. This relationship is easily accounted for if both the Arctic and Mississippi species are regarded as of northern origin.

[1]*Receptaculites oweni* Hall
Ischadites iowensis (Owen)
Plectorthis plicatella (Hall)
Hebertella borealis Billings
Hebertella bellarugosa (Conrad)
Dinorthis meedsi (Winchell and Schuchert)
[1]*Ctenodonta subnasuta* Ulrich
Cyrtodonta gibbera Ulrich
Vanuxemia abrupta Ulrich
Saffordia modesta Ulrich
Sinuites pervolutus (Ulrich and Scofield)
Tetranota obsoleta Ulrich and Scofield
Kokenospira costalis (Ulrich and Scofield)
Bellerophon similis Ulrich and Scofield
Lophospira spironema Ulrich and Scofield
Clathrospira conica Ulrich and Scofield
[1]*Maclurina manitobensis* (Whiteaves)
Maclurites crassus Ulrich and Scofield
Trochonema robbinsi Ulrich and Scofield
[1]*Fusispira inflata* (Meek and Worthen)
Fusispira nobilis Ulrich and Scofield
[2]*Cyrtoceras manitobense* Whiteaves
[2]*Eurystomites plicatus* Whiteaves
Bythocypris granti Ulrich
Nileus vigilans (Meek and Worthen)

On Igloolik island, 400 miles northwest of Frobisher bay, the Black River species *Actinoceras bigsbyi* Bronn has been identified, and 300 miles still farther west the following Black River fossils were found by the Gjoa expedition.[3]

Receptaculites oweni Hall
Halysites sp.
Columnaria sp.
Maclurea sp.
Plectoceras sp.
Actinoceras, two species
Gonioceras occidentale Hall

Maclurea arctica Haughton was found by McClintock on the west coast of King William Land.

The most interesting fossil from this area is an Orthoceroid for which the writer proposed the new generic term *Leurorthoceras*. This Orthoceroid, which has a flat ventral side, is congeneric with a species from Port Burwell which suggests a common origin for the Black River faunas of King William Land and northern Labrador.[4]

On Ellesmere island, 450 miles northeast of King William Land, *Halysites* cf. *gracilis* Hall, *Strophomena* sp., and *Maclurea* sp. suggest the presence of Black River strata.[5]

[1] Also in Manitoba.
[2] In Manitoba only.
[3] Holtedahl, Olaf, "On Some Ordovician Fossils from Boothia, Felix, and King William Land, Collected during the Norwegian Expedition of the Gjoa, Captain Amundsen, through the Northwest Passage," Videnskapsselskapets Skrifter, I, Mat.-naturv. Klasse 1912, No. 9, Kristiania.
[4] Denison Univ. Bull. 19, 1921, pp. 247-306, pls. 27-35.
[5] Holtedahl, Olaf, "On Fossil Faunas from Per Schei's Series B in Southwestern Ellesmereland," Rept. of Second Norwegian Arctic Expedition in the Fram, vol. IV, No. 32, 1913 and 1919, Kristiania.

On Norman Lockyer island, 250 miles still farther northeast of King William Land, the following Mohawkian fauna occurs, a part of which suggests Black River strata.[1]

Halysites gracilis Hall
Calapoecia canadensis Billings
Streptelasma corniculum Hall
Mesotrypa cf. *discoidea orientalis* Bassler
Hallopora angularis Ulrich
Rafinesquina deltoidea (Conrad)
Plectambonites sericeus Sowerby
Orthis tricenaria Conrad
Triplecia sp.
Rhynchotrema inequivalvis (Castelnau)
Trochonema cf. *umbilicatum* Hall.
Gonioceras occidentale Hall
Thaleops ovata Conrad
Nileus (*Bumastus* ?) sp.
Leperditia fabulites Conrad

The Black River and early Trenton faunas are widely distributed in Arctic areas. On Bear island (Figure 1) and between Norway and Spitzbergen, and about 1,450 miles from Norman Lockyer island, the following Mohawkian fauna was found, of which the *Gonioceras* suggests Black River affinities.[2]

Tetradium cf. *syringoporoides* Ulrich
Bryozoa, several species
Crinoid stems
Rafinesquina sp.
Maclurites sp.
Kionoceras sp.
Vaginoceras (?) sp.
Cyclendoceras (?) sp.
Actinoceras cf. *tenuifilum* Hall
Gonioceras cf. *occidentale* Hall
Gonioceras nathorsti Holtedahl

In this list, *Tetradium, Maclurites, Actinoceras,* and *Gonioceras* give a strongly American aspect to the Bear Island fauna. On the European continent itself, however, Mohawkian faunas having an American aspect are wanting. Their eastward migration appears to have been checked by a barrier (Figure 2) wh ch extended across the northwestern parts of Scotland and Norway toward Novaia Zemlia.[3]

In the province of Shantung in eastern China (Figure 1), 4,500 miles southwest of Norman Lockyer island, a species of *Gonioceras* and a form of *Actinoceras* related to *Actinoceras tenuifilum* Hall were identified by G. C. Crick.[4]

Recently, Prof. Amadeus Grabau, at University of Peking, China, found seven species of *Actinoceras* and eight species of *Lophospira,* with a distinctly North American facies, in the Machiakou limestone, which appears to be a Black River formation. These fossils were found in the

[1] Holtedahl, Olaf, "The Cambro-Ordovician Beds of Bache Peninsula and the Neighbouring Regions of Ellesmereland," Rept. of Second Norwegian Arctic Expedition in the Fram, vol. IV, No. 28, 1913 and 1919, Kristiania.

[2] "Notes on the Ordovician Fossils from Bear Island, Collected During the Swedish Expeditions of 1898 and 1899," published in 1918, and "On the Palæozoic Series of Bear island, especially on the Heclahook System," published in 1919; both in the Saertryk av Norsk Geologisk Tidsskrift Kristiania.

[3] Holtedahl, Olaf, "Paleogeography and Diastrophism in the Atlantic-Arctic Region during Palæozoic Time." Am. Jour. Sci., 49, 1920.

[4] Geological Magazine, London, vol. 10, 1903, p. 481.

Kaiping basin southeast of Peking. Fifty miles north of that basin, near the Manchurian border, Dr. F. F. Mathieu, of the Kailau Mining Administration, found a Beekmantown or Canadian fauna, from which Prof. Grabau lists *Piloceras, Cameroceras, Protocameroceras, Chihlioceras,* and an *Archaeocyathus* of the Mingan Island type. He observed that this northern China Ordovician has a North American facies, quite distinct from the southern China Ordovician, which is European in character.[1]

That the Black River fauna is of northern origin, and was widespread in northern latitudes, is, therefore, fairly certain, but the identification of these faunas needs revision.

In the first place, many of the identifications of strata as Black River are based upon the presence of species of *Receptaculites* identified as *Receptaculites oweni*. Typical *Receptaculites oweni* is a Trenton fossil. The Black River species is *Receptaculites occidentalis*. Dr. Ulrich[2] claims that the Richmond of Alaska and the western states contains a species of *Receptaculites* so similar to *Receptaculites oweni* that it has been distinguished only recently.

Admitting the continuity of the Black River faunas of Arctic areas from Black River to Richmond times, apparently with only little change in their appearance, it will require very careful study to determine which faunas are Black River, which are Richmond, and which are intermediate—for numerous intermediate stages must exist.

Dr. Ulrich regards it as possible that all the Arctic occurrences usually referred to the Black River are of later age. The common occurrence of a large form of *Receptaculites* is alone sufficient to suggest a later age, the Black River species being of only normal size.

Dr. Ulrich states[3] that the Stewartville member of the Trenton contains fossils that have been identified with Manitoban fossils (notably *Maclurina manitobensis* and *Receptaculites oweni*), but are not precisely similar. The Manitoba fossils are associated with a large *Rhynchotrema* similar to *Rhynchotrema capax*, and other fossils commonly regarded as indicating Richmond age, but no such fossils are found in the Stewartville member, or in any other member of the Trenton in the upper Mississippi valley.

OZARKIAN[4] AND CANADIAN ARCTIC SEAS

The chief distribution of Canadian strata lies south of the Precambrian shield. Those of Quebec, Vermont, New York, Minnesota, and Missouri appear to have had a southern origin, but those of Newfoundland, Mingan islands, Cape Breton, and New Brunswick are more directly connected with the Atlantic. Recently, however, Canadian cephalopods were identified along Bache peninsula. One of these is a new species of *Clarkoceras,* and another is a new species of Endoceroid of Canadian type.[5]

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[1] Grabau, Amadeus W., "Ordovician Fossils from North China", in Palæontologia Sinica, ser. B, vol. 1, fascicle 1, 1922.

[2] Personal communication.

[3] Personal communication.

[4] The strata referred to as Ozarkian include the Little Falls dolomite at the base of the Lower Ordovician and the Potsdam sandstone at the top of the Upper Cambrian systems. The Canadian group, a term considered useful by some stratigraphers, includes the Beekmantown of New York and the Lévis of Quebec, beneath the typical Chazyan, in the lower Ordovician.

[5] Denison Univ. Bull. 19, 1921.

A Canadian fauna has long been known from the Durness limestone of Scotland (Figure 2A). Here a species of *Piloceras* and a species strongly resembling *Protocycloceras lamarcki* Billings, described as *Orthoceras mendax* Salter, suggest Canadian affinities. *Orthoceras baculoides* Blake and *Orthoceras durinum* Blake also suggest Canadian age. Recently Holtedahl identified a characteristic Canadian fauna with an American facies on Bear island (Figure 1), between Norway and Spitzbergen,[1] and cites the following forms:

Calathium cf. *pannosum* Billings
Calathium sp.
Archæoscyphia cf. *minganensis* Billings
Crinoid stems
Maclurites sp.
Liospira sp.
Lophospira sp.
Piloceras cf. *explanator* Whitfield

Another cephalopod, identified as *Orthoceras* sp., resembles *Protocycloceras lamarcki* Billings, and another form, identified as a cyrtoceraconic shell, is a nautiloid belonging to some genus in the family Tarphyceratidae.

Here again some barrier passing diagonally across Scotland and Norway (Figure 2) would account for the absence of these Canadian forms on the continent of Europe.

Observations similar to those on the distribution of Canadian strata in Europe have been made by Holtedahl on earlier rocks of Ozarkian age. Cryptozoan-like structures, suggestive of Ozarkian or early Canadian age, occur in Finmark, on Bear island, and in Spitzbergen.[2] Holtedahl uses for these structures the general term "stromatolites" and states that stromatolitic structure is mentioned by Nathorst from strata in northeastern Greenland.[3] According to Holtedahl's map this Greenland locality is somewhere near latitude 73 degrees north. Cryptozoan-like structure was found also in a specimen from Havnefjord, southwest Ellesmereland.[4]

POLAR AND GREENLAND DEEP SEAS

The Arctic ocean occupies an area larger than the United States. The central part of this ocean, here called the Polar sea (Figure 1), descends to great depths and covers an area as large as that part of the United States east of the Rocky mountains. This Polar sea opens between northern Greenland and Spitzbergen into the deep Greenland sea, the southwest boundary of which is formed by the submarine ridge connecting Scotland with the Hebrides, Faroe islands, Iceland, and Greenland. One of the branches of the Gulf Stream drifts between Iceland and Scotland, and a return current, known as the East Greenland, flows between Iceland and Greenland, but this submarine ridge was once, perhaps, an effective barrier to the migration of faunas from the Greenland sea.

[1] "On the Paleozoic Series of Bear island, especially of the Heclahook System," 1919.

[2] Holtedahl, Olaf, "On the Paleozoic Formations of Finmarken in Northern Norway," Am. Jour. Sci., 47, 1919; and "On the Paleozoic Series of Bear Island Especially on the Heclahook System." Norsk Geologisk Tidsskrift, 5, 1919. Norsk. Geol. Fören., Kristiania.

[3] Bidrag till nordöstra Grönlands geology, Geol. Fören. Förh., Stockholm, 23, 1901.

[4] Holtedahl, Olaf, "Summary of Geological Results," Rept. Second Norwegian Arctic Expedition, in the "Fram," 1898-1902, No. 36, 1917, p. 7.

The distribution of these faunas around the shores of the Greenland sea (Figure 2), and their exclusion from areas farther southeast suggest a great age for the Greenland sea, just as the Devonian, Carboniferous, and Triassic strata along the northwest border of the Precambrian shield suggest a great age for the Polar sea.

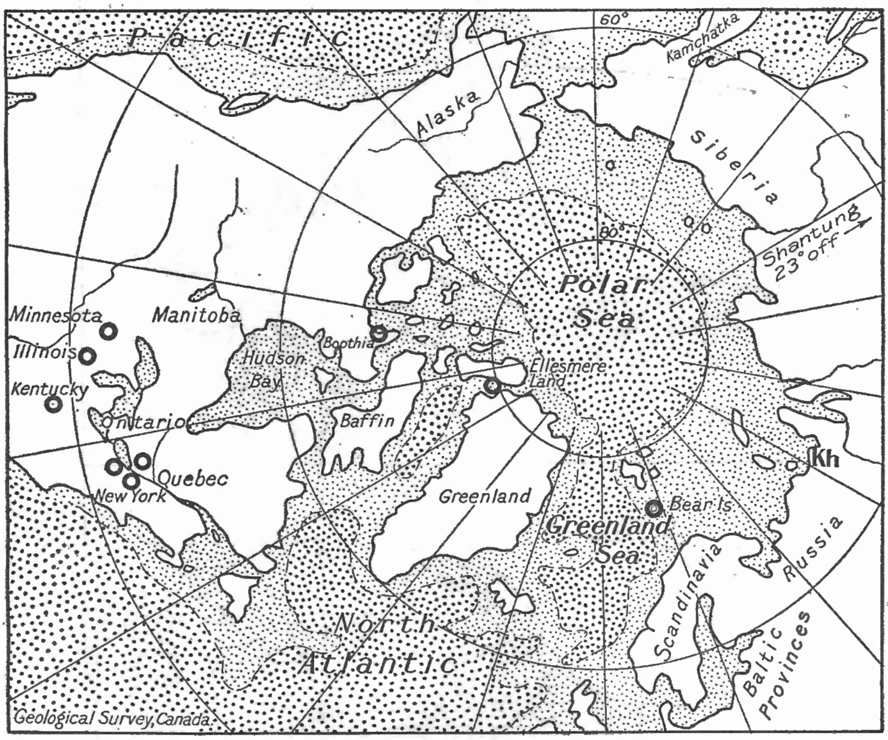

FIGURE 1. Diagram of polar regions to show (*a*) the polar and Greenland deep seas (the shallower seas are shown in light stipple, the deeper seas in the darker stipple); (*b*) the distribution of Gonioceras (indicated by circles); the occurrence in Shantung is 23 degrees off the map; the fauna at Khabarova (Kh.) is the Scandinavian-Baltic type, and not American. (After Handy Royal Atlas, W. and A. K. Johnston, London, and Olaf Holtedahl, "Notes on the Ordovician Fossils from Bear Island," 1918.)

To this Polar sea may have retreated some of those Black River species which reappear in Richmond times, at least those species which during Richmond time invaded from the north.

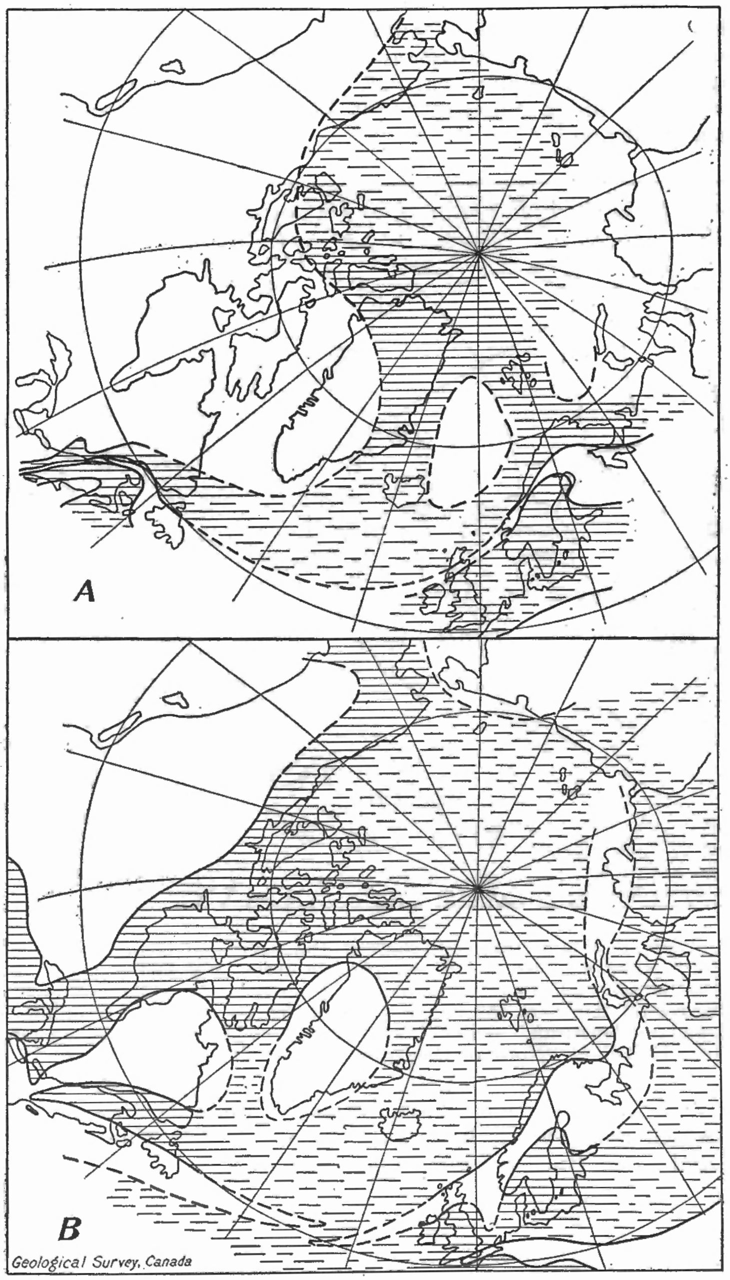

FIGURE 2. Diagrams, showing (A) extent of polar sea during Lower Ordovician, Dictyograptus (Canadian) time (after Holtedahl), (B) extent of polar sea during Middle Ordovician, Chasmops (Llandeilo or Chazyan) time (after Holtedahl).

SOUTHWESTWARD EXTENSION OF ARCTIC FAUNAS PROBABLY OF RICHMOND AGE

Southwest of Hudson bay in strata known as the Nelson River limestone is a fauna closely related to that of Lake Winnipeg region 150 miles away. The following species are common in both areas.[1]

Receptaculites cf. *oweni* Hall
Calapoecia cf. *canadensis* Billings
Columnaria calicina (Nicholson)
Columnaria (*Palæophyllum*) *stokesi* (Edwards and Haime)
Halysites gracilis (Hall)
Dalmanella testudinaria var. Dalman
Hormotoma winnipegensis Whiteaves
Maclurina manitobensis (Whiteaves)
Trochonema cf. *umbilicatum* (Hall)
Cyrtoceras manitobense Whiteaves
Poterioceras cf. *nobile* Whiteaves

According to Ulrich[2] this list indicates Richmond age. *Columnaria* of the type of *C. stokesi* and *C. thomi* is known only from the Richmond. The *Calapoecia* cf. *canadensis* may be *C. huronensis*, a Richmond form. The *Columnaria calicina* also may be the Richmond form. Both occur associated with *C. alveolata* (the Richmond form) in the Richmond of northwest Alaska. *Halysites gracilis* occurs in the Richmond of the far north and west, and a closely similar form occurs in the Middle Black River in the Upper Mississippi valley. As already pointed out, the Richmond of the north and west contains an undescribed species of *Receptaculites* very similar to *R. oweni*, and *Maclurina manitobensis* is associated in Manitoba with *Rhynchotrema* similar to *R. capax*, suggesting Richmond affinities, the species formerly identified as *Maclurina manitobensis* from the Stewartville of the upper Mississippi valley being not strictly identical.

Similar faunas appear to occur in Big Horn mountains, Wyoming, Teton range, Idaho, and Canyon City area, Colorado. From El Paso region, Texas, Ulrich identified a number of species originally listed as

Receptaculites oweni Hall
Maclurina manitobensis (Whiteaves)
Maclurina acuminata (Whitfield)
Hormotoma major (Hall)
Ormoceras sp. undet.

However, more recent studies have shown that the same beds contain *Rhynchotrema capax* and other unquestioned Richmond fossils, and that the species cited are represented by their Richmond descendants. Among these undoubted Richmond fossils from southwest Texas are:

Streptelasma cf. *rusticum* (Billings)
Hemiphragma imperfectum (Ulrich)
Rhombotrypa quadrata (Rominger)
Strophomena fluctuosa Billings
Leptæna unicostata (Meek and Worthen)
Dinorthis subquadrata (Hall)
Dinorthis proavita (Winchell and Schuchert)
Platystrophia cf. *acutilirata* (Conrad)
Rhynchotrema capax (Conrad)
Plectorthis (*Austinella*) *whitfieldi* (N. H. Winchell)
Parastrophia divergens Hall and Clarke

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[1] Savage, T. E., and Van Tuyl, F. M., "Geology and Stratigraphy of the Area of Palæozoic Rocks in the Vicinity of Hudson and James Bays." Bull. Geol. Soc. Am., 30, 1919, pp. 339-378.
[2] Personal communication.

Ulrich[1] states that this is the fauna he found associated with the *Maclurina manitobensis* fauna. The identifications were made at least fourteen years ago, and the coral then referred to *Streptelasma rusticum* and the brachiopod referred to *Platystrophia acutilirata* might not be so identified in the light of later knowledge.

Of the preceding list, *Strophomena fluctuosa, Leptœna unicostata, Dinorthis proavita,* and *Plectorthis (Austinella) whitfieldi* are known also from the Maquoketa of the upper Mississippi valley, which is regarded as a northern invasion. *Hemiphragma imperfectum, Rhombotrypa quadrata, Dinorthis subquadrata,* and *Parastrophia divergens* are listed also from the Fernvale, another northern invasion. *Hemiphragma imperfectum* and *Parastrophia divergens* are known only from the Fernvale in other areas.

RICHMOND OUTCROPS ON THE PRECAMBRIAN SHIELD

Among the fossils from Frobisher bay some ostracods suggest Richmond affinities.

On Southampton island, Hudson bay, certain grey to white, dense, magnesian rocks are regarded as of Richmond age, chiefly owing to the presence of *Leptœna nitens* Billings. The following are the species cited:

Rafinesquina alternata
Rafinesquina loxorhytis
Leptœna nitens
Zygospira sp.
Rhynchotrema sp.
Leperditia sp.
Encrinurus sp.

The southwest shores of Hudson bay are lined by Richmond strata known as the Shamattawa limestone. According to Savage and Van Tuyl, "the fossils, as well as the lithology, of the Shamattawa limestone are remarkably similar to those of the Stony Mountain limestone in the Lake Winnipeg region and correspond also with those of the Big Horn dolomite in Wyoming and those of the Montoya limestone in New Mexico. The rocks at all of these localities consist of grey to yellowish, subcrystalline limestone, with layers and mottled areas of yellowish brown dolomite. The upper part of the Fremont limestone of Colorado carries a similar fauna.

The similarity in the faunas of this age in the different localities is such as to indicate that the Richmond strata in the Colorado, Wyoming, Lake Winnipeg, and Hudson Bay regions were deposited in the same marine province or basin of deposition, which doubtless was connected at the north with the Arctic ocean. This fauna is quite different from the more or less contemporaneous fauna of the Maquoketa in the upper Mississippi valley, or from that of the Richmond farther east, in Indiana and Ohio.

When the meagre bryozoan fauna[2] in the Hudson Bay and Lake Winnipeg regions is compared with the great number and variety of species belonging to this class of fossils in the Maquoketa and Richmond strata of the Mississippi and Ohio valleys—many of the bryozoa in the latter region belonging to families not represented in the late Cincinnatian fauna of the

[1] Personal communication.
[2] *See* Palæogeographic maps VI and VII, "The Ordovician-Silurian Boundary".

Hudson Bay region—it seems impossible that the source of the Maquoketa and Richmond faunas of the eastern and central United States could have been in the north, as has generally been assumed. It is much more probable that the fauna of the Maquoketa and Richmond of the Mississippi and Ohio valleys were of southern or eastern origin, and that they invaded the interior of North America from the south.[1]

As regards the direction from which Richmond faunas invaded North America, the map prepared by Ulrich in 1913,[2] clearly illustrates his views. Evidently all the typical Richmond are regarded as invading from the south, but the Maquoketa and Fernvale as invading from the north. The Maquoketa, as used at present, includes a considerable variety of faunas among which are such characteristic northern forms as *Pleurocystites, Carabocrinus*, and *Porocrinus* from the lower Maquoketa of Clermont, Iowa.[3]

Species should be studied not only as separate entities but as parts of the faunas to which they belong. Ordinarily, species derived from different oceanic basins should show recognizable differences, even if closely related. For instance, such species as *Dinorthis subquadrata* and *Hebertella insculpta* should be resolvable into distinct forms when occurring in faunas of widely different derivation. *Dinorthis subquadrata* from the arctic invasion is not identical with *D. subquadrata* from the Cincinnatian areas, and *Hebertella insculpta* from the Maquoketa is not identical with *H. insculpta* from the Blanchester of Ohio and Indiana.

The following list by Savage and Van Tuyl, of the more common fossils from the Shamattawa limestone of Hudson Bay area, indicates also which species occur in the Stony Mountain and Big Horn areas.

Hudson Bay area	Stony Mountain	Big Horn
Streptelasma latusculum	*	
Streptelasma latusculum trilobitum	*	*
Streptelasma sp.		*
Columnaria alveolata	*	*
Columnaria (Palæophyllum) stokesi	*	*
Calapoecia canadensis	*	*
Paleofavosites asper	*	*
Halysites gracilis	*	*
Hallopora sp.		
Ptilodictya sp.	*	
Dinobolus sp.	*	
Rafinesquina cf. *alternata*	*	
Strophomena fluctuosa	*	*
Strophomena sp.		
Dinorthis aff. *subquadrata*	*	*
Platystrophia near *crassa*		
Rhynchotrema aff. *capax*	*	*
Holopea cf. *excelsa*		*
Maclurina sp.		
Trochonema cf. *umbilicatum*	*	*
Hormotoma sp.		
Raphistoma sp.		
Billingsites sp.		
Cyrtoceras sp.		
Bumastus sp.		

[1] Savage, T. E., and Van Tuyl, F. M., "Geology and Stratigraphy of the Area of Paleozoic Rocks in the Vicinity of Hudson and James Bays," Bull. Geol. Soc. Am., 30, 1919, pp. 339-378.
[2] "The Ordovician-Silurian Boundary", Twelfth Inter. Geol. Cong., Can., 1913, p. 665.
[3] The writer is indebted for the privilege of studying the cystids and crinoids collected by Ulrich and others at Clermont, Iowa.

GREAT ANTIQUITY OF GULF OF MEXICO AND HUDSON BAY EMBAYMENTS

Although the Gulf of Mexico embayment was in existence in Lower Cambrian time, it attained large proportions only in late Ozarkian time, when it extended as far north as Minnesota, Wisconsin, and the Champlain valley of New York. It reached the same dimensions during middle and late Canadian time. During early Ordovician and Chazyan times it was restricted, but became larger during the Lowville or early Black River. Then it became restricted again, but during the entire Cincinnatian, it became once more an important area of invasion.[1]

The Hudson Bay embayment, on the contrary, did not reach importance until Decorah or middle Black River times, but then it extended far south. It was the chief source of invasion again during early Trenton time, and during parts of the Richmond.[2]

The entire continent apparently was affected by some of the tectonic changes that caused either the northern or the southern embayment to become dominant, so that when the Arctic invasions extended farthest south the southern embayment was greatly restricted in area, and vice versa: tectonic changes on so large a scale cannot be explained by any factors now known.

DERIVATION OF THE SOUTHERN AND NORTHERN RICHMOND FAUNAS

It is not known whether the Richmond fauna of the north and south invasions was derived from the Black River fauna formerly occupying respectively the Gulf of Mexico and the Arctic ocean, but Ulrich, when considering this question, has written.[3]

"The Richmond faunas of the Cincinnatian region remind much more of the preceding Ordovician faunas of the same region than do the Richmond faunas in the Atlantic, the northern, and far western provinces. The faunas in the latter three provinces have much in common and indicate close relations between the northern Atlantic, and Arctic seas from which their faunas invaded. The most striking peculiarity of the Richmond faunas of the Ohioan province lies in the large number of trepostomatous bryozoa which they contain. Though Bryozoa occur also in the Anticosti Richmond, and locally in the Richmond deposits of Wyoming and Manitoba, they are chiefly of types that did not reach the Ohio and Mississippi valleys until near the close of the Richmond, in some instances, and early upper Medinan in others. However, the bulk of the Bryozoa in the Ohio valley belongs to genera, or to groups of species of certain genera like *Monticulipora, Atactoporella, Homotrypa, Bythopora, Batostoma,* and *Heterotrypa,* that are wholly unknown elsewhere in rocks of this epoch. Though specifically distinct, these bryozoa are comparable only with Trenton and Maysville species of the same genera. Indeed, we can not doubt that these Richmond forms are modified descendants of

[1] Maryland Geol. Surv., Cambrian and Ordovician, 1919.
[2] Ibid.
[3] "The Ordovician-Silurian Boundary," Compte Rendu Géol. Inter., XIIe Sess., 1913, pp. 635, 636.

known Ordovician representatives of the genera mentioned. Neither is there any reason to doubt that the Richmond occurrences of these Bryozoa invaded the area from the south just as their progenitors must have done.

"With these Richmond Trepostomata occur also species of other classes of animals that similarly indicate the southern origin of a large part of the Ohio Richmond fauna. Most of these are pelecypods, gastropods, and cephalopods, of genera that had become well established in the Ordovician faunas of the southern states, but are unknown in northern European beds of this age, and in the northern and far western Richmond deposits of North America. A few, however, did reach Anticosti during the Richmond. The more important of these surviving genera are *Byssonychia, Modiolodon, Ischyrodonta, Whitella, Cyrtodonta, Orthodesma, Cymatonota, Psiloconcha, Tryblidium, Archinacella, Bucania, Salpingostoma, Cyclonema* (typical), *Cyrtocerina,* and *Gomphoceras.*

"Despite these conspicuous molluscan and bryozoan reminders of Ordovician faunas, the Richmond faunas of the Cincinnati uplift yet comprise a host of generic and specific types that distinguishes them at once from all preceding faunas . . . . Among the characteristic species are *Streptelasma rusticum, Columnaria vacua, Protarea richmondensis, Tetradium minus* Nicholson (not Safford), *Beatricea undulata, Rhombotrypa quadrata, Rhynchotrema capax,* and *R. perlamellosa*—all widely distributed and likely to be found in any North American Richmond locality. . . . The numerous Ordovician reminders in the Indiana-Ohio Richmond are . . . . indicative . . . . of their continued existence in the southern oceanic realm and in its epicontinental extensions. At the same time it necessitates the assumption that these southern types had not then reached the Arctic centre of dispersal. So far as we know, they never did join either the Ordovician or the Silurian Arctic faunas . . . . .

"The Silurian faunas of Britain and northern Europe, likewise most of the Silurian faunas of North America, having invaded the various continental basins from the Arctic and North Atlantic realms, the reason is clearly apparent why the Silurian affinities of the Arctic Richmond faunas of the Rocky mountains and northern Canadian provinces are more prominently displayed than in the Ohio Richmond faunas. In fact, these Arctic Richmond faunas, particularly their coralline facies, have been almost invariably identified as Silurian by reputable palæontologists. . . . . When they (these Arctic Richmond faunas) are compared with their Ordovician predecessors in the Arctic fauna many simulating features are to be noted."

GREAT AGE OF ATLANTIC EMBAYMENTS

Two embayments—the Gulf of St. Lawrence and the Hudson River valley—appear to have indented the Atlantic coast as early as Cambrian time. The southern one was open in Ozarkian time. Both were open in Canadian time, at various intervals in Ordovician time, and during the Utica,[1] which was a period of invasion of northern Alantic faunas. The Eden and Maysville[2] were southern invasions, but during the period of

[1] *See* palæogeographic map No. III. "The Ordovician-Silurian Boundary." Compte Rendu XIIe. Sess., 1913.
[2] Ibid, Maps IV, V.

invasion of southern faunas into Tennessee, Kentucky, Indiana, and Ohio, an Atlantic fauna entered Pennsylvania, New York, southern Ontario, and southwest Quebec by way of Hudson valley. During Richmond time only the northern embayment was open, admitting northern Atlantic faunas to the Anticosti area.

RELATIONSHIP OF THE RICHMOND OF ANTICOSTI TO THAT OF MANITOBA

In view of the extensive Richmond faunas from the island of Anticosti, it is remarkable how few species appear to have been contributed from that area to the Richmond of Quebec and Ontario.

At Snake island, in lake St. John, 350 miles west of Anticosti, only the corals favour such an origin, and among these only *Lyopora goldfussi* is not known much farther west. In the Nicolet River section, 425 miles southwest of Anticosti, only *Strophomena hecuba* favours an origin from the Anticosti area. At Vars, east of Ottawa, *Strophomena fluctuosa*, alone, favours such an origin.

As a matter of fact, the Anticosti faunas show much closer relationship to those of Manitoba (Stony Mountain, etc.), which evidently are of Arctic origin, than to those of Quebec and Ontario. The following list includes those species which occur both in the Lower or English Head division of the Richmond on Anticosti and also in the Richmond of Manitoba. Each species is followed by the names of the other localities at which it is known.

Paleofavosites asper (Wyoming)
Arthroclema angulare (in Fernvale of Illinois)
Dicranopora fragilis (eastern Wisconsin)
Ptilodictya whiteavesi
Sceptropora facula (Wilmington and Savannah, Illinois; Tennessee, Missouri, Russian Baltic provinces)
Rafinesquina ceres
Leptæna nitens (Wyoming)
Rhynchotrema anticostiense (Wilmington and Savannah, Illinois, Iowa, Wisconsin)
Rhynchotrema perlamellosum (eastern Wisconsin, Ohio, Indiana)
Strophomena fluctuosa (Texas, Minnesota, Iowa)
Conularia asperata
Ceraurinus icarus (Iowa, Ohio, Indiana)

Among other English Head species, *Ptilodictya magnifica* is not known from the Manitoba area, but it occurs in the Richmond of Ohio, Indiana, Illinois, and Tennessee. The remaining English Head species, which occur also in western Richmond localities, are of such general distribution as not to suggest an origin in common with the Anticosti fauna. Of the species in the preceding list only *Rhynchotrema perlamellosum* and *Strophomena fluctuosa* are known between Anticosti and Manitoba, which suggests that Anticosti and Manitoba were connected by a northern channel that included both north Atlantic and Arctic waters, which must have had much in common in Richmond time.

The Middle or Vaurial (formerly Charleton) division of the Richmond on Anticosti island shows continued connexion with the Richmond of the Manitoba area, the following species being held in common.

Beatricea nodulosa (Ohio, Indiana, and Kentucky)
Beatricea undulata (Lake St. John, Manitoulin island, Ohio, Indiana, Kentucky)
Calapoecia canadensis (Lake St. John, Streetsville, Manitoulin and Drummond islands, Ohio, Indiana, Kentucky)
Columnaria alveolata (Lake St. John, Streetsville, Manitoulin and Drummond islands, Ohio, Indiana, Kentucky)
Halysites gracilis (Green Bay district of Wisconsin, and west of Hudson bay)
Bythopora striata (Ohio, Indiana, Kentucky)
Dicranopora emacerata (Ohio)
Goniotrypa bilateralis
Pachydictya hexagonalis
Clitambonites diversus
Kionoceras magnisulcatum
Poterioceras apertum
Beyrichia parallela (Ohio, Indiana)
Primitia lativia (Ohio, Indiana)
Tetradella simplex (Ohio, Indiana)

Two additional species found in the Vaurial[1] division but not known from Manitoba are of interest in this connexion. One of these is *Lyellia affinis*, known also from Frobisher bay, lake Timiskaming, and Thorold, Ont. The other is *Lyopora goldfussi*, occurring also on lake St. John, on Manitoulin island, and in Ohio.

Among the species from the Vaurial formation which occur in the Richmond exposures in northeastern Illinois, but which have not been found in Ohio, are *Helopora imbricata*, *Lioclemella nitida*, *Pachydictya firma*, and *Protocrisina exigua*, of which the last named occurs also in the Fernvale of Tennessee.

Eridotrypa simulatrix is known both from the Vaurial of Anticosti and from the Richmond of Ohio, Indiana, and Illinois. *Chasmatopora granistriata* is known from the Vaurial of Anticosti and also from the Girardeau of southwestern Illinois. This leaves only three species which occur both in the Vaurial of Anticosti and in the typical Richmond of the Ohio-Indiana-Kentucky area, but which are unknown in Illinois, the upper Mississippi valley, or farther northward.

The general relationship of the Vaurial fauna, as also of the English Head fauna, is to the Richmond of Manitoba, rather than to any Richmond farther south. Those species which occur also in the Ohio-Indiana-Kentucky area were relatively cosmopolitan and entered the Ohio basin by way of the middle Atlantic, and gulf of Mexico, passing northward from the gulf of Mexico into the Mississippi embayment, and thence into the Ohio basin.

Direct communication between the northern Richmond and the Ohio basin is indicated, according to Ulrich, only near the close of the Richmond, when a number of bryozoans of northern origin reached as far south as Sevenmile creek, south of Eaton, Ohio. There they occur in a very thin bed, recently extensively exploited by Prof. Shideler.

The Upper or Gamachian division of the Richmond has little in common with Richmond faunas elsewhere, except in the case of those species

[1] Geol. Surv., Can., Bull. No. 33, 1921, p. 4.

which were already present during Vaurial time and which continued their existence into the overlying Gamachian or Ellis Bay division.

The following species showing European affinities are listed by Prof. Twenhofel from the Vaurial of Anticosti and the Lyckholm of the Baltic provinces.

Calapoecia canadensis
Halysites catenularia
Paleofavosites asper
Streptelasma rusticum
Zaphrentis affinis
Corynotrypa dissimilis
Nematopora lineata
Protocrisina exigua
Sceptropora facula
Clitambonites diversus
Plectambonites sericeus
Pseudolingula elegantula
Byssonychia sp. nov.
Sinuites cf. *bilobatus*
Calymene meeki
Proetus alaricus

LITHOLOGICAL CHARACTERISTICS OF THE UPPER ORDOVICIAN STRATA

EDEN AND MAYSVILLE IN SOUTHERN ONTARIO

On Manitoulin island and along the southern shore of Georgian bay, the lower part of the Sheguiandah or Eden formation consists of shale or clay, and only the extreme top contains limestone in any abundance. This limestone is locally richly fossiliferous, resembles, lithologically, the thin limestones in the Eden of Ohio, Indiana, and Kentucky, and contains a few of the same species, thus resembling the Eden more closely than do those strata of about the same age, near Toronto, which form the basis of an important brick industry. There are also limestones, but they are much more argillaceous than the limestones forming the top of the Sheguiandah formation. Moreover, although the total thickness of the Sheguiandah on Manitoulin island probably does not exceed 125 feet, the Eden formation in the Toronto area is at least 300 feet, and may be more.[1]

In the northern part of New York, that part of the Lorraine section which is referred to the Eden formation is still thicker, and consists almost entirely of clay shale.

The Maysville member of the Upper Ordovician on Manitoulin island is only about 150 feet thick, is rarely well exposed, and consists chiefly of shales interbedded with argillaceous limestone, containing, as a rule, fossils on the lower or upper surface only.

In the typical Pulaski shales, forming the lower part of the Maysville portion of the Lorraine, the clay shales are more indurated and the argillaceous limestones tend to be more gritty, as though supplied with very fine-grained arenaceous material, but in general there is no great lithological difference until the overlying strongly arenaceous Oswego part of the section is reached.

[1] "Upper Ordovician Formations in Ontario and Quebec," Geol. Surv., Can., Mem. 83, 1916, p. 77.

OSWEGO SANDSTONE AS A SUBAERIAL DELTA DEPOSIT

Nearly unfossiliferous sandy and argillaceous deposits occur in Upper Ordovician strata on a large scale in Maryland, Pennsylvania, New York, southwestern Quebec, and southeastern Ontario. Some of these deposits are of considerable thickness. One of these, mostly grey, has been called the Oswego sandstone. Along the western slope of Tuscarora mountain, Pa., it is 150 feet thick and it rests on strata containing *Orthorhynchula linneyi*, a characteristic fossil of the lower or Fairview member of the Maysville formation. It is overlaid by soft, red, unfossiliferous sandstone and red shale regarded as of Richmond age, and, therefore, corresponds to the upper or McMillan division of the Maysville.

At Salmon River falls, N.Y., the thickness of this sandstone exceeds 107 feet. At Niagara, N.Y., it is 75 feet thick and westward of this it soon disappears.

Grabau[1] regards these sandstones as deposited in very shallow water, and as of subaerial rather than submarine origin. They consist of nearly pure quartz, derived apparently from the old Appalachian highlands toward the east and southeast. Prof. Grabau writes:

"If we admit the Appalachian source of the Oswego sands for the eastern region, we must admit it for western New York as well, and, for the same reason, we must connect these sandstones with the Bald Eagle fan. For such a deposit of pure sands calls for a corresponding, though not necessarily as pure, a deposit nearer the source. It is also logical to assume that such a deposit should become coarser and thicker as we approach the source of the material. There is no sandstone or conglomerate in the Appalachians which fits these requirements and is at the same time of the corresponding age, except the Bald Eagle. Even if we regard this formation as a submarine delta deposit, against which interpretation all its characteristics protest, we must consider that the lower part of the series is of less aerial extent than the upper, for this is true of submarine as well as subaerial delta deposits, and so we come to the inevitable conclusion that the Oswego sandstone of New York represents the higher beds of the Bald Eagle deposit. The lineal distance between the two regions is not over 160 miles, which is not excessive for such deposits . . . . . The influence of the currents bringing the quartz sands of the Oswego was evidently not felt in the Quebec region, where continuous deposition went forward."

In north-central New York, the Oswego sandstone rests directly on Pulaski shale, the upper part of which carries a fauna that includes, apparently, some of the species from the Fairview of Ohio.

A mile and a half southeast of McConnelsville, Pa., the following species occur at the *Orthorhynchula* horizon immediately below the Oswego sandstone.[2]

Plectorthis plicatella Hall	*Byssonychia praecursa* Ulrich
Catazyga erratica Hall	*Allonychia ovata* Ulrich
Ischyrodonta unionoides (Meek)	*Modiolopsis modiolaris* (Conrad)
Pterinea demissa (Conrad)	*Modiolodon truncatus* (Hall)
Byssonychia radiata (Hall)	*Orthodesma nasutum* (Conrad)

[1] Grabau, A. W., "Early Paleozoic Delta Deposits of North America," Bull. Geol. Soc. Am., 24, 1913, p. 425.
[2] Bassler, R. S., Cambrian and Ordovician; Maryland Geol. Surv., 1919, p. 170.

Some of these species are characteristic of the top of the Pulaski formation at its typical exposures in New York.

In southern Pennsylvania the formation of delta deposits evidently began during the deposition of the Fairview member, for grey sandstones, about 300 feet thick, here occupy the interval between the upper Eden and the *Orthorhynchula* horizon. Even the upper Eden is described as consisting here of shale and calcareous sandstone.[1]

ARENACEOUS HORIZONS IN THE EDEN AND MAYSVILLE OF OHIO AND KENTUCKY

Arenaceous horizons occur also in the Eden and Maysville formations of Ohio and Kentucky, though their constituents are so fine-grained as to be recognized readily only in strongly weathered specimens. In central Kentucky, for instance, the upper or McMicken member of the Eden consists of massive, argillaceous and somewhat siliceous, very fine-grained limestone, which appears arenaceous on weathering. On analysis it shows a considerable silica content. Apparently only such fossil forms remain as could live in fairly muddy waters. Their Eden age is attested by the presence of *Dekayella ulrichi* and other characteristic species. The overlying strata of argillaceous limestones interbedded with clay are, however, much more fossiliferous. Their Maysville age is indicated by *Strophomena maysvillensis* and other fossils which in Ohio begin their range in the Mount Hope member of the Maysville. Since both the McMicken and the Mount Hope members were included under the term Garrard sandstone, as originally applied in the Richmond folio of Kentucky, the writer proposed the term Paint Lick for the lower or McMicken member, which alone is characteristically sandy in east-central Kentucky, from Bath county to Boyle county. West of this line, the corresponding strata are more calcareous and more fossiliferous.

Another nearly unfossiliferous arenaceous horizon, between the top of the Fairview and the base of the McMillan, may be traced from Adams county, Ohio, where it goes under cover, to Boyle and Casey counties in central Kentucky. For this horizon the writer proposed the term Tate member, and assumed that it corresponded to the Bellevue member of the Maysville formation. In the case of this Tate member, also, the western representatives of the arenaceous strata are more calcareous and fossiliferous.

Both the Paint Lick and Tate deposits suggest an outwash from land farther east. In other words, the arenaceous strata of eastern Kentucky, in passing beneath the later deposits of the Alleghany plateau, should become more coarsely arenaceous.[2]

SOURCE OF SEDIMENTS FORMING THE QUEENSTON SHALE

According to Williams[3] the Queenston red clay shale thins from 860 feet at Buffalo to 160 feet southeast of lake St. Clair, and to 200 feet west

[1] Bassler, R. S., Cambrian and Ordovician; Maryland Geol. Surv., 1919, p. 173.
[2] Foerste, A. F., "Strophomena and Other Fossils," Bull. Denison Univ., 17, 1912, pp. 17-23.
[3] Geol. Surv., Can., Mem. 111, 1919.

of Owen Sound. This suggests that the Queenston thins in a northeasterly direction at a rate of 4·7 feet per mile. As a matter of fact, most of the thinning takes place near Buffalo, the rate from Buffalo to the area between Guelph and Elora being 5·5 feet per mile, whereas the northwestward thinning about 15 miles south of Georgian bay is only 1 foot per mile.

The Queenston shale was formed by material that came apparently from southeast of the Ontario peninsula. Some land mass probably extended along what are now the Atlantic states, as far south as the gulf of Mexico. Along the western margin of this land mass, deposits—of which the Queenston apparently was one—were formed upon the land itself. It contains no evidence of marine life except in the Ontario peninsula, where a few thin bands contain marine species, and evidently represent oscillations of the land that permitted eastward extensions of the marine waters.

In Ontario the sandstone is not as coarse as in some horizons in Pennsylvania, and Ordovician marine sedimentation came to a close with the *Orthorhynchula* bed at the top of the Fairview; the overlying grey sandstone of the McMillan division is unfossiliferous and corresponds to the Oswego sandstone of New Nork. Above the Oswego lies the Juniata formation, consisting of soft, red, unfossiliferous sandstone and red shale, interbedded, and also unfossiliferous. This formation corresponds to the Queenston shale of southern Ontario, and, therefore, is regarded as of Richmond age. Above the Juniata occurs the Tuscarora sandstone, corresponding to the Oneida and Shawangunk conglomerates of New York, all of which are regarded as later than Richmond.

Red clay shales referable to the Queenston occur 2 miles south of Vars, 15 miles east of Ottawa, and near St. Hyacinthe, Que., where a well bored for oil is stated to have passed through 1,000 feet of these shales before reaching the dark grey Waynesville and Lorraine strata. In neither of these areas was it possible to determine the total thickness of the Queenston, since it is overlain by no limiting strata.

Southwest of Ste. Monique, on Nicolet river, the equivalent of the Waynesville member is overlain by Queenston shale that may be 1,000 feet thick, but here again no limiting overlying strata occur.

Ells[1] refers to red shales and sandstones of Medina age (Queenston), and states that in concession Beauséjour, 10 miles south of Three Rivers, a well passed through 565 feet of red clay shale, again without limiting strata above.

The most easterly exposures of the Queenston occur about 25 miles east of Three Rivers, or 450 miles east of the extreme northwestern exposure on Georgian bay.

The former horizontal continuity of the Queenston shales, now intermittently exposed, is suggested by the fact that their bases always rest on Richmond limestones containing a Waynesville fauna, and wherever Waynesville strata occur, no Ordovician strata of later age, excepting the Queenston, are known.

[1] Ells, R. W., "Geology of the Three Rivers Map-sheet," Geol. Surv., Can., Ann. Rept., vol. XI, pt. I, published in 1900; page 21J.

RELATIONS BETWEEN FAUNAS AND THE SEDIMENTS IN WHICH THEY OCCUR

RELATIONS BETWEEN FAUNAS AND THE CHARACTER OF THE SEA BOTTOM

The composition of littoral faunas varies in different localities, and most of these variations are due to heat and light. Certain species depend on certain temperatures. Along the New England coast, for instance, some species are exposed to Arctic currents, whereas others thrive in waters warmed at times by the Gulf Stream. Some species flourish in shallow waters, exposed to both heat and light, and others are found chiefly in the depths.

But heat and light are not the only causes of variation. Certain species prefer turbulent waters, which others systematically avoid. Certain forms demand clear waters, others prefer muddy. Some burrow, some require solid supports for growth, and some, again, seek waters more saline than do others.

Although the character of the sea-bottom may affect the ready growth of a few burrowing species, or those of sedentary habits, it is not likely to have had more than local influence on the distribution of species. The character of a fauna introduced by some epicontinental sea will almost certainly be determined by its temperature and salinity; and it is rarely that the character of a sea-bottom deters a species from entering an embayment.

Assuming, then, that the species are not influenced by the sea bottom, except locally, there should be little direct connexion between the components of a fauna and the character of the sediments enclosing them: species should occur indifferently in clays, shales, sandstones, or limestones, provided that all other conditions were the same, while these species were alive.

It must be admitted that little is known concerning the conditions of the waters in which these fossil faunas lived. Our knowledge is mainly confined to the fact that they occur in sediments of a varied character, and if any connexion is assumed between the character of a fauna and its enclosing sediments it is purely an assumption.

The Cincinnati formation contains hundreds of layers of limestones and clay in both of which the faunas appear to be impartially distributed. It is true that the tops, and especially the bottoms, of the limestone layers provide the best-preserved species, but this is merely because these fossils clung to the firm surfaces of limestone and can be gathered intact, whereas the same species, collected from the clay, are likely to fall to pieces.

Some limestones consist largely of somewhat comminuted shells and other organic remains, from which the clay has been removed in part by currents, and contain fossil fragments that have rounded edges. The valves of brachiopods are almost always dissociated; the carapace of trilobites is dismembered; the surface features of bryozoans are obscured, but no difference in faunal content from the interbedded clay shales is noted.

The fauna of the Oriskany sandstone is not very different from such faunas as occur in limestones or shales.

Of course, lithological conditions do influence faunal content—and naturally so—but the changes are influenced not so much by the sea-bottom as by salinity, temperature, depth, currents, etc.

Any change in the lithological composition of successive strata infers important changes in the areas from which the sediments were derived—changes in the depth of the waters, their salinity, their temperature, or connexion with oceanic sources of faunas. In other words, change of lithological character, as a rule, indicates changes affecting the composition of marine faunas, but is no proof that change in the character of the ocean floor was the determinative factor. It is imperative that these facts be kept in mind to interpret the statements made in the following paragraphs.

LAMELLIBRANCHS OF THE LORRAINE MUD-DEPOSITS

In southern Pennsylvania and in Maryland, the Eden formation (lower part of the Lorraine) consists of about 400 or 500 feet of interbedded yellow shale and calcareous sandstone, of upper Eden age. This is underlain by an equal thickness of middle and lower Eden strata consisting of soft, greenish to yellow, shaly sandstones and shale. Among forty-two species listed by Bassler from the top of the Eden and from an horizon 400 feet lower, only five are lamellibranchs. These are *Ctenodonta obliqua*, C. *filistriata*, *Clidophorus planulatus*, *Byssonychia vera*, and *Lyrodesma conradi*. Among other significant fossils are *Cryptolithus bellulus*, C. *recurvus*, *Triarthrus becki*, and *Calymene granulosa*.

Southeast of McConnellsburg, the Eden shales and sandstones are overlain by grey sandstones, 450 feet thick, of Maysville age. Fossils including *Orthorhynchula linneyi* and *Plectorthis plicatella*, occur 300 feet above the base of the Maysville formation. Since these fossils characterize the top of the lower or Fairview division of the Maysville formation in Kentucky, it is evident that about 300 feet of the Maysville section near McConnellsburg belongs to the Fairview member, whereas the overlying 150 feet probably belongs to the upper or McMillan member. Of the eighteen species of fossils listed by Bassler from the *Orthorhynchula* horizon at McConnellsburg, eight are lamellibranchs. These include *Ischyrodonta unionoides*, *Pterinea demissa*, *Byssonychia radiata*, *B. praecursa*, *Allonychia ovata*, *Modiolopsis modiolaris*, *Modiolodon truncatus*, and *Orthodesma nasutum*. This evidently is the fauna found near the top of the Pulaski shales, directly beneath the Oswego limestone, in the area west of Salmon River falls, New York, and, therefore, assists in indicating the McMillan age of the Oswego sandstone in New York, and the McMillan age of the Pulaski shales of that state.

If account be taken of the dominant fossils found in the Lorraine, rather than of the faunal lists published from this horizon, then the dominance of various species of lamellibranchs becomes obvious. This predominance of lamellibranchs is characteristic not only of the typical Lorraine of north-central New York, but also of the contemporaneous shale deposits in the Ottawa basin and in southern Quebec. Such species as *Byssonychia radiata*, *Clidophorus planulatus*, *C. praevolutus*, *Ctenodonta lorrainensis*, *Lyrodesma poststriatum*, *Modiolopsis* cf. *concentrica*, *Phola-*

domorpha pholadiformis, and *Pterinea demissa* are not only widespread, but occur in countless numbers. Other species of lamellibranchs rarely occur in great numbers, but occur at a great number of localities over a wide area, a few specimens at each locality. This is true, for instance, of various species of *Cymatonota* and *Psiloconcha.* Some species of lamellibranchs may be fairly common at certain horizons, but these horizons may be of relatively limited vertical extent, as, for example, *Ischyrodonta unionoides, Modiolopsis modiolaris,* and *Orthodesma nasutum.* Certain genera are represented by several species, nowhere known to be common, but each genus, as a group, is scattered over a considerable territory. These genera include, in addition to others already mentioned, such as *Cuneamya, Rhytimya,* and *Whitella,* certain species, such as *Colpomya faba pusilla;* and various species of *Cymatonota, Psiloconcha, Rhytimya,* and *Whitella,* which at present are known from relatively few localities, probably will be discovered eventually at numerous other localities, scattered over a wide area.

In fact, the Lorraine may be regarded as a lamellibranch formation; or a formation in which lamellibranchs predominate. This is true, as shown by Miss Stewart,[1] even as far west as Toronto.

It is assumed that, during the Lorraine, conditions were very favourable for the development of lamellibranchs. Only a few of the lamellibranchs burrow in mud. Specimens of *Cymatonota,* with gaping ends, occur not infrequently in a vertical position in the enclosing sediments. Species of *Byssonychia, Eridonychia, Allonychia, Anomalodonta, Opisthoptera,* and *Psiloconcha,* on the contrary, had byssal openings and evidently were attached to some support. *Pterinea,* during life, always lay on its right valve, which was thinner than the left valve and quite flat. Many species evidently were free, and crawled around on the sea-bottom, as do most living species.

BRACHIOPODA OF THE LORRAINE FORMATION

The brachiopods of the Lorraine are relatively few, excepting in the case of a small number of species. The more common species include *Catazyga erratica, Dalmanella* cf. *fultonensis, Pholidops subtruncata, Plectambonites* cf. *rugosus, Rafinesquina mucronata,* and *Zygospira modesta. Leptæna moniquensis* is common only in certain arenaceous layers in the lower or Eden part of the Lorraine. *Glyptorthis crispata* (Emmons) is common only at the horizon exposed at the level of the village of Lorraine and immediately below. *Rafinesquina alternata* occurs at many horizons in the Lorraine, but usually only a few specimens occur at any one locality. The six species mentioned first have great vertical ranges. They occur in all kinds of sediments and presumably accommodated themselves to very different conditions of temperature, salinity, clarity of water, and, possibly, depth. Holtedahl[2] discusses the distribution of different species of the Strophomenidæ in various sediments of the Christiania region. The species under consideration belong chiefly to the genera *Rafinesquina,*

[1] Stewart, B. H., "The Stratigraphy and Paleontology of Toronto and Vicinity;" Twenty-ninth Ann. Rept., Ont. Bureau of Mines, pt. VI.

[2] Holtedahl, Olaf, "The Strophomenidæ of the Kristiania Region," Videnskapsselskapets Skrifter, I, Mat. Naturv. Klasse, No. 12, 1916, pp. 103-106.

Strophomena, *Plectambonites*, and *Leptæna*, all of which existed during Lorraine time. Holtedahl states that of seventy forms of Strophomenidæ in the Christiania region forty-nine have been found in limestone only, nine in shale only, and twelve occurred in both, but more commonly in the limestone. He concludes from this that clear salt water of moderate depth gave the most favourable biological conditions. This includes not only ordinary limestones but also arenaceous limestones. *Christiania tenuicincta*, however, is found in greater numbers and better developed in shale, and the largest specimens of *Plectambonites transversalis*, also, occur in shale. In very fine-grained, black shales, such as the graptolitic shales, the Strophomenidæ are nearly or totally absent. Holtedahl concludes that foul bottom and great depth certainly were not favourable conditions for the Strophomenidæ. Graptolites are pelagic forms. They mostly occur in dark strata, the dark colour being due to carbonaceous material. Vegetable fouling was probably common. Great depths, however, may not have been present. On the other hand, cool climates may have existed.

In the Ordovician strata of New York, between the basal Beekmantown and the top of the Utica, Ruedemann distinguishes between the graptolite facies, largely shale, containing pelagic organisms and the littoral facies, largely limestone, containing a much greater variety of species.[1]

In the dark coloured Lorraine shales of the Ottawa basin and in southern Quebec, *Rafinesquina alternata* is only an occasional fossil, although the smaller species *Rafinesquina mucronata* is common in the *Proetus* and *Pholadomorpha* zones, particularly on the limestone surfaces.

Plectambonites is very common at many horizons. *Leptæna moniquensis* occurs only in certain arenaceous layers in the upper part of the *Cryptolithus* zone and in the overlying *Leptæna* zone. This species belongs to the same group as *Leptæna rhomboidalis*, a group which continued its existence for a very long time, under a great variety of physical conditions. In fact, those forms which can live under the most varied conditions should have long vertical ranges. Among other groups occurring embedded in all kinds of sediments, and having great vertical ranges are certain species of *Dalmanella*, represented in the Lorraine of Canada by a species related to *Dalmanella fultonensis*, and the group typified by *Zygospira modesta*.

One of the most ubiquitous species of the Lorraine of southern Quebec, the Ottawa basin, and the Toronto area is *Catazyga erratica*, followed in the Waynesville member by *Catazyga headi*. This species occurs chiefly in thin argillaceous strata, but was occasionally detected in the interbedded clay shales.

Certain genera, well represented in the Maysville of Ohio, Indiana, and Kentucky, are rare or absent in the corresponding part of the Lorraine section of Canada.

None of the species of *Strophomena* occurring in the Eden and Maysville formations of Ohio, Indiana, and Kentucky belong to the *Strophomena planumbona* group. The latter is represented in the Trenton by *Strophomena trentonensis* Winchell and Schuchert, and *Strophomena vicina* Foerste, and then disappears in Eden and Maysville times, reappearing as *Strophomena concordensis* Foerste at the close of the Arnheim member of the

[1] New York State Mus. Bull. Nos. 227, 228, 1921, p. 130.

Richmond, and as *Strophomena planumbona* during the Clarksville division of the Waynesville. *Strophomena vetusta* also occurs in the Richmond.

A second group of Strophmenoids, typified by *Strophomena planoconvexa,* is represented in the lower and middle Eden by *Strophomena hallie* and *Strophomena millionensis;* in the Mount Hope and Fairmount by *Strophomena maysvillensis* and *Strophomena planoconvexa,* and in the upper Fairmount by *Strophomena sinuata.* It recurs in the Richmond formation in the form of *Strophomena sulcata.*

The first group is known in the Lorraine of Canada only at a few localities, and horizons. In the *Proetus* zone it is fairly common at the mouth of Huron river, and one specimen was found in the Nicolet River section. It occurs on Huron river apparently also at a higher horizon, belonging either to the *Pholadomorpha* zone or to the Waynesville member of the Richmond.

The second group of Strophomenoids (*Holtedahlina*) typified by *Strophomena planoconvexa,* is known in southern Canada only from Richmond horizons, where it is represented by *Strophomena sulcata* and related species.

Species of *Platystrophia* occur in such great variety and abundance in the Maysville of Ohio, Indiana, and Kentucky, that it may be designated as the *Platystrophia* formation. In a similar manner, the Fairview member is characterized by *Plectorthis,* but neither *Platystrophia* nor *Plectorthis* is known from the Lorraine of New York, or Canada.

Species usually identified with *Hebertella sinuata* and *Hebertella occidentalis* are abundant in the Maysville of the Ohio-Indiana-Kentucky area. Nevertheless, none were found in the Lorraine of New York or the Ontario peninsula, and only a few in the Lorraine of southern Quebec, though occurring occasionally in the *Proetus* and *Pholadomorpha* zones.

The scarcity of *Strophomena, Platystrophia, Plectorthis,* and *Hebertella* from the Lorraine of New York and Canada is unlikely to be due to the character of the sea-bottom, for in the typical Cincinnatian areas of Ohio, Indiana, and Kentucky they occur in equal abundance in the limestones and clays, and are known elsewhere in sandstones and shales. Some other factor, therefore, must have prevented not only the brachiopoda named, but many other characteristic Maysville forms, from reaching New York and Canadian areas.

The arenaceous deposits of the Ohio-Kentucky-Indiana area have already been referred to. Although they were highly unfavourable to life, it is doubtful if they were laid down in muddy waters, but their faunas were, apparently, affected by other conditions, such as salinity, temperature, and depth. Among the forms most tenacious of life were *Hebertella* and *Platystrophia,* abnormal in form, surface markings, and size; others, less numerous, were *Rafinesquina alternata* and *Zygospira modesta* also, though not so conspicuously, robust. The *Hebertella* and *Platystrophia* were, probably, attached by pedicles of unknown lengths. The pedicles of *Zygospira modesta* appear to have been 3 or 4 mm. long, for numerous individuals were found that surrounded a single column of a crinoid or a single stem of a bryozoan in such a manner that their beaks all pointed inward and extended to within 3 or 4 mm. of their supposed supports. *Rafinesquina,* on the other hand, appear to have led a free existence, for at certain horizons countless numbers, apparently carried by currents, have been stacked up as closely as possible, in an approximately perpendicular position.

GASTROPODA AND CEPHALOPODA OF THE LORRAINE

With the exception of the patelliform species *Archinacella pulaskiensis*, no gastropod is common in the Lorraine of Ontario and Quebec. Among species with coiled shells, *Cyrtolites .ornatus* and *Sinuites cancellatus* are most common. *Cyclonema* is known only from the Lorraine-like strata at Weston, west of Toronto, although in the typical Cincinnatian areas of Ohio, Indiana, and Kentucky seven species of *Cyclonema* are found in the Fairview division, followed by two species in the McMillan.

East of Pulaski, N.Y., various species of Orthoceroids, belonging chiefly to the genus *Loxoceras*, occur in the limestones interbedded with the shales. Cephalopods are rare in the shales themselves. In the same manner, in the Weston area, Orthoceroids occur in the more calcareous layers. Elsewhere in Ontario and Quebec, only occasional specimens of cephalopods are found. Evidently the muddy bottoms of the Lorraine were deposited under conditions unfavourable to cephalopod life, but it need not be assumed that the mud itself constituted this unfavourable condition.

TRILOBITES OF THE LORRAINE

Southwest of Ste. Monique de Nicolet, Que., a species of *Cryptolithus* resembling *C. bellulus* much more than *C. concentricus* occurs at various intervals in strata exposed for a thickness of 800 feet, but whose total thickness is unknown. This *Cryptolithus* zone belongs apparently to the Southgate member of the Eden. A similar form occurs at about the same horizon in the Don Valley brick-yard near Toronto. The layer containing *Cryptolithus*, in the Workman Brook section, west of Meaford, probably belongs to the same horizon also.

Cryptolithus occurs at various levels in the Lorraine of New York. In the Pulaski division is found a form in which the posterior margin of the cephalon curves more strongly backward toward the genal angles than in *Cryptolithus bellulus*. In this respect it resembles *C. recurvus* Ulrich, from which, however, it may differ in other particulars. The Pulaski division is correlated with the Fairview, so that its *Cryptolithus* must be of later age than any other known species.

According to Ulrich[1] nine-tenths of the specimens of *Cryptolithus* in the United States National Museum came from nearly pure limestone. But *Cryptolithus* also occurs abundantly, in sandstones and shales, thus indicating that the character of the bottom had little influence on the life of these trilobites.

Prof. Raymond, however, is of the opinion that *Cryptolithus* was accustomed to burrow in mud, and his contention is supported by the fact that occasionally the trilobite swallowed mud sufficient to distend its digestive tract so as to permit of its recognition even in the fossil state. The absence of eyes might also be due to this burrowing habit.

[1] Personal communication.

Triarthrus is found so frequently associated with *Cryptolithus* that it, also, may have been a crawling rather than a freely swimming animal. Both genera occur not infrequently in the same strata as graptolites. In southern Quebec a species of *Triarthrus* resembling *T. eatoni* occurs in the *Cryptolithus* zone, at an horizon belonging to the Southgate member of the Eden formation.

Calymene is another trilobite that occasionally swallowed mud and thus left traces of its alimentary canal, as in a few of the specimens studied by Dr. C. D. Walcott. *Calymene* has a great vertical range and occurs in all kinds of sediments.

In the Nicolet River section, *Proetus chambliensis* has a vertical range of 467 feet. It is associated here with *Dekayella ulrichi*, a characteristic Eden species. In Ohio, *Proetus parviusculus* is common in the Fairmont member, and similar forms occur in the Cynthiana formation, at the top of the Trenton, in various parts of Kentucky, and in the Eden formation of Ohio, Indiana, and Kentucky.

Triarthrus, *Calymene*, and *Proetus* are regarded by Raymond[1] as trilobites with small pygidia, and chiefly crawlers and slow swimmers. *Isotelus* he regards as an animal living on the sea-bottom, having a crawling habit, but able to swim. Considering its abundance and vertical range in Ohio, Indiana, and Kentucky, it is remarkable how few specimens are found in the Lorraine of New York, and southern Canada.

Attempts to explain the faunal contents of strata by lithological differences have not been very successful. That such differences did affect certain species may be admitted, but the absence of certain species in certain strata is due, not to the unsuitable bottom, but to the absence of routes by which the fauna could invade those waters.

CORALS AND STROMATOPOROIDS OF THE RICHMOND FORMATION

In Ohio, Indiana, and Kentucky, corals are distributed widely in varying abundance throughout the Richmond formation, the distribution being, apparently, dependent on some unknown phenomena that also affected the lithological character of the sediments.

Where richly fossiliferous limestones and clays prevail, only species of *Streptelasma* and *Protarea* are likely to be common, and such species as *Columnaria*, *Calapoecia*, and *Tetradium* are relatively rare and almost invariably small. This is true especially in Ohio, where richly fossiliferous limestones abound, but where sandy phases are uncommon and of small extent. In the character of its environment, *Stromatocerium* falls in line with the massive corals, and, therefore, frequently is mentioned in discussions dealing with these species.

In the more arenaceous phases of the Richmond, however, especially on the western side of the Cincinnati geanticline, there are several conspicuous coral horizons, the individual masses of which are large.

In this area there are three main coral horizons of which the lowest is near the base of the Waynesville. The massive corals here consist chiefly of *Columnaria*, but at certain localities *Tetradium* is common. This

[1] Raymond, P. E., "The Appendages, Anatomy, and Relationships of Trilobites," Memoirs of Connecticut Acad. Arts and Sci., 7, 1920, p. 103.

horizon, called by the writer the Fisherville coral reef, after the village near which the typical exposures occur, extends from Henry county, Kentucky, to Nelson county, and is overlain by 10 feet of shale, containing little except *Cyphotrypa clarksvillensis* Ulrich.

The lowest 5 feet of the Liberty member in this part of Kentucky consists of very fossiliferous limestone, and 5 feet farther up there is a widespread horizon in which *Columnaria* is common, frequently in association with *Calapoecia.* Locally, one or more additional coral horizons occur farther up. Some of the overlying strata of the Liberty are abundantly fossiliferous. The coral horizons themselves, however, contain little beyond the corals. The writer has called this lowest Liberty zone the Bardstown coral reef: it extends from Jefferson county, Kentucky, to the middle of Casey county.

Above the lower part of the Saluda member is another *Columnaria* reef, and above that a *Tetradium* horizon. *Calapoecia* is common at some localities in the *Columnaria* layer. This Saluda zone, called by the writer the Madison coral reef, extends from Jefferson county, Kentucky, through Osgood, Indiana, and thence northward: it is mostly overlain by a shale bed 10 to 15 feet thick.

A fourth coral horizon, containing *Tetradium,* occurs in southern Indiana, from near Canaan to Laurel.

When the corals in these horizons are abundant, other fossils are rare or absent. Similar conditions were noted in the Richmond on Snake island in lake St. John, Que.; also at Streetsville, Ont.; and at various localities on Manitoulin island.

These massive corals appear to have thrived only in waters that were neither very clear nor very muddy.

As soon as a thick deposition of clay or sand begins, the large corals drop out completely, or coraliferous layers and argillaceous layers alternate in a manner suggesting alternation of conditions favourable and unfavourable to coral life. If thick deposits of clay usually indicate rapid, rather than long continued, deposition, this would account for the relatively abrupt extinction of coral life so characteristic of these zones, although, of course, the various alternations of strata might have resulted from changes in elevation of the sea-bottom.

The conditions that both favoured the deposition of richly fossiliferous limestones and were detrimental to the growth of massive corals are not known, but the following observations are pertinent:

In Ohio, Indiana, or Kentucky, wherever the limestones are strongly ripple-marked, *Columnaria, Calapoecia,* and *Tetradium* are rare and seldom exceed 3 inches in diameter. The specimen of *Calapoecia cribriformis* figured by Nicholson[1] may, judging from its size, have been an Ohio specimen.

Most of these massive corals appear to have grown near argillaceous sea-bottoms, for the coraliferous layers occur both above and beneath the argillaceous deposits, and several successive coral horizons are found alternating with argillaceous layers. Apparently the massive corals lived sufficiently near the argillaceous areas to be among the first invaders in case of a sinking land mass, and among the last to leave along a rising shore.

[1] Geol. Surv., Ohio, Pal. II, 1875.

Assuming that the argillaceous and arenaceous material along the western side of the Cincinnati geanticline was deposited nearer the shore than were the fossiliferous limestones in Indiana and Ohio, the so-called coral reefs of the Richmond must also have been formed nearer the shore and were more exposed to muddy waters. The Kankakee axis, which separated the Richmond deposits of Ohio, Indiana, and Kentucky from those of northern Illinois and the upper Mississippi valley, probably ran slightly west of Louisville. The absence of Brassfield deposits in Ripley and Jennings counties, Indiana, and the presence of conglomeratic layers at the base of the overlying Niagaran formations also indicate the presence of land.

The structure of *Columnaria calicina* goes to prove the proximity of the coral zones of the Richmond formation to land conditions. *Columnaria calycina* is merely a pathological phase of *Columnaria alveolata*, in which some of the corallites become somewhat free. This condition was caused by the failure of certain corallites to bud with sufficient frequency to keep those of the same corallum crowded together laterally. Where crowding is sufficient, the outlines of the corallites are polygonal. Where crowding is not sufficient, the corallites assume their natural cylindrical forms. This failure to bud freely characterized particularly the more depauperate specimens, where the growth of the corallum suggests lack of vitality. *Columnaria calicina* appears to be frequent only where argillaceous sedimentation began long before the corallum had reached more than moderate size.

The distribution of corals was probably largely dependent on the direction and extent of the currents, and the reefs extended into the epicontinental basins as far as the currents carried the young corals, which, if conditions were favourable, began to form the reefs.

Stromatocerium, although not a coral, has the same habitats as *Columnaria*, *Calapoecia*, and *Tetradium*, and forms equally large growths. *Stromatocerium*, associated with *Tetradium*, occurs in the *Orthoceras fosteri* zone, a 5-foot clay layer at the base of the Clarksville division of the Waynesville. In western Kentucky it occurs in the Bardston coral reef. Large specimens are common in the upper part of the Saluda and Elkhorn formations. It is abundantly represented at several horizons in that part of the Richmond of Manitoulin island which is correlated with the Whitewater and Saluda formations of the Indiana area. It occurs in the lower part of the Whitewater at Streetsville, and on Snake island.

Beatricea occurs at various horizons in the typical Richmond, but is most widely distributed in the Bardston coral reef, although occurring also in other low parts of the Liberty and near the middle of the Elkhorn members. Its growth in tall vertical columns proves that it lived in relatively quiet waters.

STATIONARY CORALS

The heavy, stony part of Ordovician corals—especially the large massive ones—was sufficient to prevent them moving from place to place, unless, if unattached, they were transported by currents.

The larvæ of corals are free and are carried readily by currents. When ready for metamorphosis into the actinian form they become attached, and begin to secrete their stony skeleton. Their growth is chiefly upward, and to variable extents also lateral, their lower surfaces—even in the massive corals—usually being limited by an epitheca.

In *Columnaria* that side of the corallites which faces the basal epitheca usually is flat, but occasionally presents a somewhat semi-cylindrical form, in accordance with the tendency of all free corallites. In its initial stages, the centre of origin of the corallum, the apex of the first corallite, is in many cases attached to some object, but subsequent growths of the corallum are unattached along their lower epithecal surfaces and the corallum finally remains stationary, chiefly on account of its flattish bottom and considerable weight.

In *Calapoecia* the bottom of the corallum more frequently is convex, the entire corallum being nearly globular. Only the lower side is covered by an epitheca, and in its initial stages attachment was made only by the initial corallite, and possibly by one or two adjacent ones. *Lyopora goldfussi* had a basal epitheca and a form similar to that of *Calapoecia*. Even in *Tetradium* an epithecal layer is present. In massive forms of *Tetradium* this epithecal layer is confined to the bottom of the corallum. In the discrete or branching species, the epithecal layer covers the sides of the groups of corallites. These groups tend to be arranged so as to present quadratic cross-sections. Specimens of this type are common in the Perryville formation in central Kentucky, and similar forms occur at the top of the Trenton, at Little Current, on Manitoulin island.

Stromatocerium, though not a coral, has a form of growth similar to that of the massive corals. Its initial stages were attached at a small central point, but larger specimens have nearly flat bases, covered with an extremely thin epithecal layer, and remain stationary owing to their weight.

Beatricea grew in unbranched vertical columns, the tapering base being much shorter than the more slowly tapering upper part. Probably its weight sunk the base into the mud, for specimens of *B. nodulifera*, found 3 miles southeast of Lebanon, Kentucky, were still in their original vertical position in the rock. They were fairly common there and were 50 mm. in diameter. Their original length was about 60 to 70 cm. On Anticosti island, *Beatricea* have been found more than 10 feet long and 8 to 10 inches in diameter. Since these growths remained erect, the waters must have been quiet for long periods.

The Trenton species of *Protarea* grew like small *Stromatoceria*, unattached except at a small central point. Successive layers in many places were approximately discrete. The encrusting habit did not prevail until Richmond time. Richmond species of *Protarea* begin like thin layers of *Dermatostroma* encrusting some shell or other organism, but subsequent growths instead of forming discrete layers develop depression resembling calyces. On this account *Protarea* usually is classified as a coral.

SOME SIMPLE CORALLA APPARENTLY NOT PERMANENTLY ATTACHED

The oldest coral known from American strata is *Tetradium simplex* Bassler, from the lower Beekmantown. *T. syringoporoides* Ulrich occurs in the middle and upper Stones River division of the Chazyan. *Stylarea* *parva* (Billings) occurs in the Lenoir in the middle Stones River, *Columnaria alveolata* is cited from the Lebanon limestone in the upper part of the Stones River. Between the top of the Stones River and the base of the Lowville in Maryland is wedged the *Caryocystites* bed, containing *Tetradium columnare* and *Columnaria halli*. The overlying Lowville contains *T. cellulosum* and the earliest known simple coral, *Streptelasma profundum*. From this it is evident that compound corals as diverse as *Tetradium*, *Stylarea*, and *Columnaria*, belonging to three different families, and classified in two distinct sub-classes, were in existence before the first known simple coral. It is generally assumed, however, that the simple corals, although as yet undiscovered, must have preceded the compound ones. In the Black River, *Calapoecia canadensis*, another compound coral, makes its first appearance. This belongs to a fourth family.

The simple corals begin in the Lowville with *Streptelasma profundum* and occur in the Leray (*S. apertum* and *Lindströmia whiteavesi*); in the Platteville (*S. breve* and *S. parasiticum*); in the Trenton (*S. corniculum*); in the Waynesville (*S. rusticum* and *S. divaricans*); in the Whitewater (*S. divaricans*); and in equivalents of the Richmond. The compound corals in the Richmond include *Protarea*, *Halysites*, *Lyellia*, *Plasmopora*, *Palæofavosites*, and *Lyopora*.

If the simple corals preceded the compound ones their tardy appearance among fossil forms, and the slow evolution of new genera, demand explanation.

Among the earlier simple corals *Streptelasma parasiticum* is attached conspicuously in an oblique direction along the flat lateral side of the corallum, whereas *S. divaricans* is attached by a flat base, from which it grows upward in a nearly cylindrical form.

According to Winchell and Schuchert, the point of attachment of *S. profundum* in many specimens is well shown. Regarding *S. corniculum* they state: "Several immature individuals of this species have been found growing on *Rhinidictya*, and occasionally an adult specimen will show traces near the base of the corallum of its former attachment to some bryozoan. That species of this genus are attached to foreign bodies, at least during their earlier growth, is almost certain. As the point of union is very small, it is also quite probable that the individuals, on reaching maturity, became broken off by the weight of the corallum."

Several species of *Streptelasma* are figured and described as having a base terminating with a point, no mention being made of a terminal attachment area. In the case of *S. rusticum* the attachment areas usually are on the cardinal side of the pointed end of the coral, and rarely exceed 2 or 3 mm. in diameter. Apparently their weight broke the corals from their supports long before maturity. Few specimens show attachment areas, even when well preserved as far as the very tip of the acute base, so that either the initial attachment areas must have been minute or many individuals never were actually attached by means of their calcareous skeletons.

The number of coral species which at maturity were unattached is probably much greater than generally supposed. This would be more readily appreciated if investigators were to make special search for specimens of every species showing attachment areas. Numerous individuals of Silurian, Devonian, and Carboniferous simple corals fail to show attachment areas. Relatively few specimens show attachment areas large enough to have served as a support for mature specimens.

There is no evidence that any coral ever possessed tentacles strong enough to enable it to travel or to burrow its pointed end downward, causing the polyp to face upward. Most specimens must have lain on their sides; no other position could have been one of stable equilibrium. From this position, later growths of the coral not infrequently were directed angularly upward, in a geniculate manner.

Perhaps small corals, with flat cardinal sides, such as the Silurian genera *Calceola* and *Holophragma*, were carried easily by currents. Small, laterally flattened species, such as *Zaphrentis digoniata* Foerste, were also, probably, moved about by currents.

In a lengthwise direction, the cardinal side of the simple corals usually is curved convexly, and the opposite side concavely. Some investigators believe that the attachment of simple corals in their initial stages to foreign objects, by their cardinal sides, gave rise to this direction of lengthwise curvature and to the general method of intercalation of the septa in the *Tetracoralla*. But the earliest known simple corals show terminal, rather than cardinal, attachment.

Regarding *Streptelasma profundum* Winchell and Schuchert state: "In the Canadian specimens of this species the corallum is very little or not at all curved, and the same is true of Minnesota individuals occurring in the Trenton limestone and the lower part of the shales immediately above. In Wisconsin, however, where it is quite abundant near the base of the 'Upper Buff' beds in well-preserved specimens, the curvature is more often as great as in *S. corniculum* Hall. The point of attachment in these is often well shown, but is generally smaller than in that species."

Streptelasma apertum was a rapidly expanding erect species. *S. breve* was a rapidly expanding oblique form, apparently with basal, instead of cardinal, attachment.

The *S. rusticum* on Snake and Manitoulin islands show much less curvature than those in the Richmond of Ohio, Indiana, and Kentucky.

RECURRENT FAUNAS, BRIEF INVASIONS, AND REGIONAL ABSENCE OF SPECIES

THE RICHMOND LARGELY A RECURRENT BLACK RIVER AND TRENTON FAUNA

The fact that many Black River and Trenton genera recur in the Richmond, but not in the Eden or Maysville formations, has been known for many years. The recurrent fossils include *Calapoecia, Columnaria, Protarea, Streptelasma, Rhynchotrema, Cyrtodonta, Vanuxemia, Helicotoma, Oxydiscus, Vallatotheca, Billingsites, Oncoceras, Spyroceras, Zitteloceras, Drepanella, Eurychilina, Leperditella,* and *Leperditia.*

In a similar manner, certain species well known in the Richmond find their nearest representatives in the Black River or Trenton formations. For instance, *Hebertella insculpta* finds its nearest relative in *H. bellarugosa* from the Black River of Wisconsin, Minnesota, Iowa, Kentucky, and Baffin island. *Dinorthis subquadrata* finds its nearest relatives in *D. ulrichi* from the upper Trenton of Kentucky, and *D. meedsi* from the Trenton of the upper Mississippi valley. *D. carleyi* finds its nearest relative in forms identified from the Trenton of New York and the Ottawa basin, as *D. retrorsa*. The various species of *Strophomena* belonging to the *S. planumbona* group are unknown in the Eden and Maysville formations of typical Cincinnatian areas. *S. planumbona* finds its nearest relatives in *S. trentonensis* from the Trenton of the upper Mississippi valley, Kentucky, Tennessee, and New York. *S. neglecta* finds its nearest relative in *S. incurvata* from the Black River of numerous localities extending from Tennessee to southern Ontario.

Leptæna richmondensis finds its nearest relatives in *L. invenusta* from strata in Kentucky which are regarded as lower than the typical Eden of the Cincinnati area, and in an unnamed species from the lower Trenton of New York and Tennessee. *Leptobolus occidentalis*, from the Richmond of the Mississippi valley, finds its nearest relatives in *L. insignis* from the Utica of New York and the Fulton of the Cincinnati area, and in *L. lepis* from the upper Trenton of the Cincinnati area.

Certain genera from strata earlier than the Eden and from the Richmond, are known also from the Leipers division of the Maysville in Tennessee and southern Kentucky. *Girvanella*, for instance, occurs in the upper Fairmount in a typical Leipers fauna several miles east of Junction City, Kentucky. *Stromatocerium* and *Tetradium* occur in the typical Leipers fauna on Cumberland river, Kentucky. Earlier forms of *Girvanella* are known from the Chazyan of New York and Vermont. *Stromatocerium* is of very general distribution, but the early forms of massive species of *Tetradium* are chiefly from Tennessee.

Among genera unknown from Eden or Maysville strata, *Calapoecia* occurs in the Black River formation of the Ottawa basin, and in Baffin island. *Columnaria* and *Streptelasma* occur in the Black River and Trenton over wide areas, both north and south. *Protarea* occurs in the Trenton of New York, the Ottawa basin, and Minnesota. On Cloche island, northeast of Manitoulin, it occurs near the top of the Black River.

The species nearest *Rhynchotrema capax* is *R. increbescens* which is widely distributed in the Trenton. *R. dentatum* is represented in the Trenton of New York and New Jersey by a form so similar as to be indistinguishable.

Helicotoma is represented by numerous species ranging from the Canadian to the Trenton. In the Richmond it is rare. *Oxydiscus* is represented by species ranging chiefly from the Canadian to the Trenton, but two species have been described from the Richmond. *Salpingostoma* is represented by four species in the Black River and Trenton and four species in the Richmond. *Vallatotheca* is represented by a single species in the upper Trenton of Kentucky, and by a single species from the Richmond of Manitoulin island.

Billingsites canadensis was described from the Richmond of Anticosti. It finds its nearest relatives in species described under *Ascoceras* from the Black River of Shamattawa river west of Hudson bay, and from the Lake Winnipeg area. *Oncoceras* finds its ancestors in strata ranging from the Chazyan to the Trenton, from Minnesota and Wisconsin to New York and Quebec, and as far north as Baffin island. *Spyroceras* is known from the Chazyan, Black River, and Trenton from Iowa to New York and Quebec. *Zittelloceras* is known from the Black River and Trenton from Missouri to New York and the Ottawa valley.

Drepanella ranges from the Stones River to the Black River, chiefly in Kentucky and Tennessee, but also in Minnesota. *Eurychilina* ranges from the Stones River to the Trenton from New York to Minnesota and as far south as Tennessee. *Leperditella* ranges from Stones River to Trenton, from Minnesota to Quebec, and south to Tennessee. *Leperditia* ranges from the Canadian to the Trenton, and from Minnesota to Newfoundland, as far south as Tennessee and north into Canada. All these ranges include only the distribution in strata older than the Eden.

LOCATION OF BLACK RIVER AND TRENTON FAUNAS DURING EDEN AND MAYSVILLE TIMES

What became of the Black River and Trenton genera that are absent in the Eden and Maysville formations? The source of these faunas was not the epicontinental seas, but the oceanic basins with which these seas communicated. The epicontinental faunas were exterminated at times either locally or regionally, according to the diastrophic changes, but they did not disappear from the oceanic basins, which replenished the seas again and again, giving rise to what is known as the recurrence of faunas.

If the Richmond fossils which represent recurrences of Black River and Trenton forms had a northern distribution, it may be assumed that during Eden and Maysville times these forms existed in northern waters, from which later they replenished the Richmond seas. This applies to all those Richmond deposits which are the result of northern invasions. The faunas of the typical Richmond areas which entered by way of the gulf of Mexico are also shown on this plate.

Some of these southern faunas were originally of northern origin, but during Eden and Maysville times gradually extended their ranges southward, so that when the southern Richmond invasion took place they were able to enter the Mississippi embayment, and progress as far north as Ohio, and later, southern Canada.

Among such northern corals are: *Calapoecia* which first makes its appearance in the Bardston reef; *Lyopora* in the upper part of the Waynesville; and *Protarea* and *Streptelasma rusticum* seen first at the base of the Clarksville. It is possible the *Calapoecia* and *Lyopora* also appeared in the Upper or Middle Waynesville of Ohio and they certainly were present in the Waynesville of Manitoulin island.

Stromatocerium pustulosum and *Tetradium* are southern forms usually found in association. Ulrich[1] claims that this is so in the upper Bigby, in the three Cathys coral zones, in the Leipers in Tennessee and southern Kentucky; in the corresponding Fairmont at Cincinnati, and in the several Richmond zones; but these forms never occur in faunas that invaded from the north or northeast. *Stromatocerium* occurs in east-central Kentucky in the Arnheim, and at one locality as low as the Mount Auburn.

[1] Personal communication.

S. rugosum, on the contrary, is a north Atlantic type, that during the middle Chazyan progressed as far south as Tennessee, and in Black River time as far south as Tennessee and Alabama, but is never found with *Tetradium.*

Columnaria, and to a more limited degree also *Dinorthis,* are southern types, that during Eden and Maysville times travelled northward until in Richmond time they reached the Polar seas. Those found in the Mississippi embayment, however, came in from the south, by way of the gulf.

At Clifton, Tennessee, *Columnaria alveolata* is associated with *Dinorthis carleyi, Rhynchotrema dentata,* and *Leptæna richmondensis precursor,* in the middle Arnheim. In Kentucky, it is known first in the lower part of the Waynesville, but in Ohio is rare in the upper part.

Dinorthis ulrichi, which occurs in Kentucky in the upper part of the Bigby, is closely allied to *D. subquadrata* which makes its first appearance in the Mississippi embayment at the base of the Liberty. The Trenton species, *Strophomena vicina,* also found in the upper part of the Bigby, recurs in the form of *S. planumbona,* in the lower part of the Clarksville. *Vallatotheca unguiformis,* from the Flanagan of Kentucky, recurs as *V. manitoulini,* in the Waynesville of southern Ontario.

Since the Black River and early Trenton faunas are mostly of northern origin, it is natural that Black River faunas having an American facies should be found also on Bear island, off Norway, and in northern China, and it may eventually be possible to determine Richmond faunas in European and Asiatic areas. The presence of *Calapoecia canadensis, Columnaria fascicula, Streptelasma* cf. *corniculum, S. europaeum,* and *Protarea* cf. *vetusta* in the Lyckholm of the Russian Baltic provinces, suggests such a circumpolar element in strata regarded as corresponding approximately to the Vaurial on Anticosti.

During Black River and Trenton times the North American continent apparently was tilted so as to admit epicontinental seas, chiefly from the north. During Eden and Maysville times it appears to have been tilted in an opposite direction. Northward tilting brought in again the Black River and Trenton faunas during Richmond time. Of course, events were not altogether as simple as suggested by these statements. Epicontinental seas deriving their faunas from different sources were no doubt present on different parts of the continent at the same time. The invasions that extended over the wider areas were probably due to tiltings that more or less excluded faunas from other directions. It is unlikely, for instance, that the major northern Richmond invasions were strictly contemporaneous with the major southern Richmond invasions. Although it is possible to determine their relative ages only where they overlap, their approximate age may be determined even when the strata are nowhere in contact. The recognition of the Fernvale as of earlier age than the Waynesville was made possible only by the fact that, according to Ubrich, in a small area in northwestern Tennessee the Fernvale is found directly underlying the Waynesville.

BRIEF INCURSIONS OF FAUNAS

Although it is certain that the geological record is nowhere complete, yet studies in the field, if sufficiently close, give evidence of frequent shiftings of faunas. Some faunal incursions appear to have been of very short duration. For instance, although *Catazyga headi* seems to have a great vertical range in Quebec, and the genus appeared there in early Upper Ordovician time, yet in Ohio and Indiana it is known only in a zone about a foot thick, at the base of the Blanchester, though it may possibly occur a few feet below this horizon.

In Ohio and Indiana *Hebertella insculpta* appears first in a thin zone at the base of the Blanchester; again in a thin zone at the top, and a third time locally about 18 feet above the top of this division, although the corresponding species in the upper Mississippi valley is recorded as having a much more continuous range.

Austinella scovillei, an eastern representative of the Upper Mississippi Valley species *A. kankakensis* and *A. whitfieldi*, appears in Ohio just beneath the second occurrence of *Hebertella insculpta*, another form with western relations.

Dinorthis carleyi appears first in the middle of the Arnheim member of the Richmond formation, but occurs again, associated with *Hebertella insculpta*, at the base of the upper or Blanchester division of the Waynesville member, where *Hebertella insculpta* makes its first appearance. Here both species are associated with *Catazyga headi*. The last is known elsewhere only from the Waynesville member of Manitoulin island; at Streetsville; in the Ottawa basin; in southern Quebec; on Snake island in lake St. John; and on Anticosti island—all northern areas. Its precursor, *C. erratica*, is known only from the Lorraine of New York, and southern Canada, having a considerable vertical range in Quebec. *Hebertella insculpta* is common at the base of the richly fossiliferous part of the Waynesville on Manitoulin island, but does not occur farther east than Meaford. It is cited from northeastern Illinois, Wisconsin, Minnesota, and Iowa, where it is represented by a distinct, but closely related, species in the Fernvale and in the lower and middle Maquoketa of Savage's reports. *Dinorthis carleyi* is widely distributed in the Arnheim, but is known in the Waynesville only in northern Ohio and Indiana. Ancestral forms of *D. carleyi* occur in the Trenton of Snake hill, Saratoga county, New York, and are cited by Billings from the Trenton at Ottawa, Belleville, and L'Orignal. Another near relative, *D. retrorsa*, was described from the Bala of southern Wales.

Strophomena planumbona is so common throughout the Clarksville division and in the lower part of the Liberty, that its absence in the intermediate Blanchester member where *S. nutans*, *S. neglecta*, and *S. vetusta precursor* come in, is significant. It reappears at the beginning of the Liberty, after the other species named have disappeared in turn. It apparently belongs to a different faunal group.

In the Nicolet River section, *Leptæna* is found in thin arenaceous layers occurring at intervals of 465, 105, 75, 185, and 180 feet, in descending order. In the lowest 50 feet of the fourth interval, *Leptæna* also occurs in small numbers and in numerous layers. *Cryptolithus* is unknown above the 180-foot interval. In this case the species did not, apparently, abandon the entire area, but chose those parts represented by the arenaceous layers, that were best suited to its existence. At any rate the faunas in those layers are not strikingly different from the faunas occupying the intermediate argillaceous shales.

This, however, is not the case with such fossils as *Dinorthis carleyi, Hebertella insculpta, Austinella scovillei, Catazyga headi, Strophomena nutans, Strophomena neglecta,* and *Rhynchotrema dentatum,* which are always accompanied by other species that are unknown in intermediate areas.

It seems, therefore, that such species belong to distinct faunas that had access to these areas only for brief intervals, and are, naturally, found only in the thin layers.

Any single geological formation may contain several distinct faunules, some of them with small vertical range but of wide geographic distribution. It is important to learn what species "go together," especially when the same species reappear for brief periods at frequent intervals. *Hebertella insculpta,* for instance, is known only from the typical Richmond areas in Ohio, Indiana, Kentucky, Manitoulin island, and the southwestern part of Georgian bay, but its nearest relatives in Richmond time occur in northeastern Illinois, Wisconsin, Minnesota, and Iowa, and in other areas belonging to the Mississippi Valley basin. *Catazyga headi,* on the contrary, has chiefly a northeast distribution, and *Dinorthis carleyi* is known first, in Richmond strata, in the Arnheim, which is distinctly a Gulf invasion. The occurrence of these fossils in the same stratum, at the base of the Blanchester, could be explained, probably, if all the fossils associated with them in the Cincinnati geanticline and elsewhere were also known.

REGIONAL ABSENCE OF SPECIES COMMON ELSEWHERE

The absence or scarcity of *Plectorthis, Platystrophia,* and *Hebertella* in the Lorraine of New York and Canada is significant in view of their abundance in the Maysville of Ohio, Indiana, and Kentucky, and indicates that the Lorraine of these northern areas secured its faunas chiefly from some Atlantic source, rather than from the gulf of Mexico.[1] Significant, too, is the absence of *Dinorthis subquadrata* south of Georgian bay, in the Ottawa basin and in southwestern Quebec, for it is abundant in the Liberty and lower Whitewater members of Ohio, Indiana, and Michigan. Closely related species occur in Wisconsin, Illinois, Minnesota, Iowa, Missouri, Manitoba, and on Anticosti. Possibly this means that the upper part of the Richmond on Manitoulin island does not belong to the Liberty or to the lower Whitewater, but corresponds to the Saluda member, in which *Dinorthis subquadrata* is either very rare or absent.

Leptæna richmondensis is unknown in the Richmond of southern Canada, though abundant at numerous horizons in the Richmond of Ohio, Indiana, and Kentucky.

[1] The presence of Lorraine species in the Bellevue of Ohio may indicate that some part of this Atlantic fauna found its way as far westward as typical Cincinnatian areas, and not that the typical Lorraine of New York secured its lamellibranch fauna chiefly from the southwest. From this point of view, the typical Lorraine of New York, and the corresponding deposits in southern Ontario and Quebec may be regarded as belonging to different basins of deposition, characterized by partly independent faunas. Ulrich, E. O., "The Ordovician and Silurian Boundary," Inter. Geol. Cong., Can., Sess. of 1913, published in 1914, pp. 623, 629.

Dalmanella jugosa and *Plectambonites* are abundant throughout the Waynesville formation in typical Cincinnatian areas. The few depauperate specimens found in the Waynesville on Manitoulin island are distinguished as a distinct species.

Strophomena planumbona is plentiful in typical Cincinnatian areas, but few of the specimens of *Strophomena* on Manitoulin can be referred to this species. The same may be said of *S. nutans*, *S. neglecta*, and *S. vetusta*. The upper Fairview species *Orthorhynchula linneyi* is fairly common from Tennessee and Kentucky northeast to Pennsylvania, but is very rare at Cincinnati and is not known north of that city.

VERTICAL RANGE OF CERTAIN CANADIAN LORRAINE SPECIES

The considerable vertical range of *Cryptolithus* in the Lorraine of New York and southern Canada should be noted. In Ohio, Indiana, and Kentucky *Cryptolithus* is common in the Cynthiana, Fulton, and lower Eden formations, but is absent in the upper Eden and in the Maysville. It occurs, however, not only in the lower Lorraine of New York (corresponding to the Eden of Cincinnatian areas), but also in the upper or Pulaski division (corresponding to the lower Maysville of Cincinnatian areas), where it is associated with *Modiolopsis modiolaris*, *Ischyrodonta unionoides*, and *Orthodesma nasutum*—all characteristic Pulaski species. The highest Pulaski stratum in which *Cryptolithus* is known is regarded by Ulrich as of about the same age as the Bellevue. This would ascribe to *Cryptolithus* a greater vertical range in the Lorraine section of New York than anywhere else in North America. Its vertical range in the Eden of the Nicolet River section is 800 feet, but it is not known to occur in the Maysville of Quebec or Ontario.

Cryptolithus bellulus (Ulrich) was described from the Economy member of the Eden at Covington, Kentucky, and *C. recurvus* Ulrich occurs there in the lower part of the Eden formation, but is known there also near the top of the Trenton. No specimens of *Cryptolithus* from the Lorraine of New York agree precisely with either *C. bellulus* or *C. recurvus*. They more nearly approach *C. recurvus*, although specimens from the lower Lorraine in the Nicolet River section agree more nearly with *C. bellulus*. Further study may lead to the erection of several new species.

The total vertical range of *Proetus chambliensis* in the Eden of Nicolet River section is 440 feet. Its nearest relative, *P. parviusculus*, is common in the Fairmount, and forms not readily distinguishable occur also in the Eden and the upper Trenton at Cincinnati, and in Kentucky.

Rafinesquina mucronata ranges in the Nicolet River section from the top of the *Leptæna* zone to the top of the *Pholadomorpha* zone, a total of nearly 800 feet, including strata ranging from lower or middle Eden to the base of the Richmond. The corresponding species, *R. squamula* James, was described from 350 feet above low-water mark of the Ohio at Cincinnati, where it occurs in the Fairview. Similar specimens occur at different horizons in the Eden. It may be assumed, as a general rule, that when the vertical range of a species is much greater in one area than in another, the direction of migration was from the greater to the smaller. For instance, *Cryptolithus* and *Triarthrus* may be assumed to have migrated from New York to Ohio. *Platystrophia ponderosa* and *Orthorhynchula linneyi*, on the contrary, are supposed to have migrated from southern areas northward and northeastward.

But this determination of direction requires corroboration. In Ohio, for instance, *Austinella scovillei* is confined to a layer less than 3 inches thick, located about 5 feet below that layer of *Hebertella insculpta* which forms the top of the Waynesville. In Iowa, the range is about 85 feet. It occurs at different intervals associated at most horizons with a species resembling *H. insculpta*, and at several horizons with a species related to *Dinorthis subquadrata*. Since *D. subquadrata* does not occur in Indiana or Ohio below the Liberty, the inference is that the Mississippi Valley species of *Austinella* are younger and, therefore, could not have been the source of supply for the Ohio Valley species. The Mississippi Valley species belong to Arctic faunas, whereas the Ohio Valley species entered from the south.

It was Ulrich who first realized that the epicontinental seas were supplied with faunas from the inexhaustible sources of the oceanic basins, and it was he who first suggested the approximate fixity of the major embayments and their frequent, though intermittent, use as routes of travel. Other investigators, especially Schuchert, Clarke, Ruedemann, and Weller, have collaborated or carried on independent researches. The writer has attempted to present such of their ideas as relate directly to the paleogeography of Upper Ordovician strata, with the object of supplementing them with the results of his own labours in Ontario and Quebec.

CORRELATION OF CANADIAN UPPER ORDOVICIAN STRATA WITH TYPICAL CINCINNATIAN STRATA

MANITOULIN ISLAND

The Upper Ordovician formations of southern Ontario and Quebec nowhere closely resemble—either lithologically or faunally—those of the Ohio-Indiana-Kentucky area. In Manitoulin island, however, the resemblance is more apparent and the exposures on Saugeen peninsula, between Georgian bay and lake Ontario, occupy an intermediate position, in lithology, in faunas, and geographically.

SHEGUIANDAH FORMATION

The only fairly continuous section of Upper Ordovician strata on Manitoulin island begins in the southeast part of Little Current and for 3 miles follows the shore road to Sheguiandah, whence it continues westward for a farther 3 miles. The section begins, at the base, with the typical Collingwood black shale, containing *Ogygites canadensis* (Chapman). Ten feet above the shale, *Triarthrus eatoni* comes in, accompanied by a species of *Leptobolus* (*L. insignis* Hall?). The shale gradually becomes softer and less dark, up to 37 feet above the base, where the last specimens of *L. insignis* are seen. Ordinarily, the first occurrence of *Triarthrus eatoni* over the typical Collingwood is regarded as the beginning of the

Gloucester shale deposition of Canadian areas. If this lower part of the Sheguiandah formation can be correlated with any part of the Ohio section, it would be with the Fulton shale, which also contains *L. insignis*.

Between 107 and 112 feet above the top of the Collingwood shale, *Byssonychia vera*, *Cyrtolites carinatus*, and *Calymene granulosa* make their first appearance, associated with the bryozoan *Amplexopora persimilis*, *Coeloclema commune*, *Hallopora onealli sigillarioides*, *Hemiphragma whitfieldi*, and a *Stigmatella* near *clava* or *nana*. These fossils indicate an Eden fauna, apparently of Southgate age. The strata containing this fauna consist of numerous thin layers of limestone interbedded with soft clay. Since this change from black shale to light, soft clay begins immediately over the uppermost *Leptobolus* horizon, about 70 feet above the top of the Collingwood, the intervening 30 feet of clay also is regarded as of Southgate age, although it contains only a few limestone layers from which no characteristic fauna has been collected. How far upwards the Southgate fauna extends is not known, but exposures elsewhere on the island suggest that the upper part in which the limestones are more abundant may be 30 feet thick.

WEKWEMIKONGSING FORMATION

At an elevation of 183 feet above the top of the Collingwood shale, *Pholadomorpha pholadiformis* was found. Species identified by Ulrich as *Bythopora gracilis* and *Bythopora dendrina* were found 2 feet lower. On the basis of these two bryozoans, the *Pholadormorpha* horizon was regarded by Ulrich as of middle Maysville age. The same horizon is exposed at other localities on the island, but it furnishes a varied fauna, at only one place, about three-quarters of a mile south of Clay cliffs, where the faunas consist chiefly of lamellibranchs, and a few doubtful species. It is, therefore, as well to regard the reference of the *Pholadomorpha* or Wekwemikongsing formation as only tentative. Provisionally it is regarded as somewhere near the Bellevue in position. Its thickness is at least 40 feet, but at no point has either the base or top been definitely determined.

Lithologically, the Wekwemikongsing formation resembles the so-called Lorraine as exposed along Humber river, west of Toronto. Indurated argillaceous limestones are interbedded with argillaceous shales. The limestones are fine grained, 2 to 4 inches thick, and many of them are fossiliferous only along their lower and upper surfaces. They weather light brown, and then present a somewhat fine-grained arenaceous appearance.

MEAFORD FORMATION

This formation, named from the exposures near Meaford, Ont., although better exposed on Manitoulin island, includes the lowest horizon of the Richmond in southern Ontario, up to the base of the Gore Bay reef. On Manitoulin island these lowest horizons contain *Hebertella insculpta*, often associated with or just below *Catazyga headi*. *Strophomena planumbona*, *S. neglecta*, *S. nutans*, and *S. sulcata* occur, in small numbers, associated with numerous specimens of *S. huronensis*. *Platystrophia clarksvillensis* and *Zygospira kentuckiensis* are present. On the basis of this fauna the Meaford limestone on Manitoulin island is correlated with the upper division of the Waynesville, although at Meaford it may include also lower parts of that member.

KAGAWONG FORMATION

It is assumed that the Gore Bay reef is the base of a new faunal zone, notwithstanding that all the corals characterizing this zone occur also at lower horizons, though in fewer numbers and of smaller size. Above this coral reef the strata become more arenaceous, although this arenaceous element is very fine-grained and does not result in a granular texture.

Strophomena vetusta and *Ceraurinus marginatus* occur 3 miles south of Little Current, just above this Gore Bay reef. The *S. vetusta* resembles the typical upper Liberty and Whitewater forms and not their upper Waynesville precursors. The *C. marginatus* finds its nearest relative in *C. meekanus* in the basal part of the Whitewater. The specimens of *Beatricea* found at various elevations in the Manitowaning area find their nearest relatives in the Liberty and Saluda members. Certain Ostracods, such as *Leperditia caecigena* and *Primitia lativia*, and some of the lamellibranchs in the upper part of the Richmond on Manitoulin island, suggest Saluda and Whitewater age. In the absence of species characteristic of the Liberty formation alone, the relationship of the Kagawong formation appears to be with the Whitewater or Saluda. In southern Indiana, the Saluda overlies the southern representatives of the Whitewater and apparently merges northward into the Elkhorn, but Cumings regards these appearances as deceptive, and has traced it northward into the Whitewater area.[1]

WEST OF TORONTO

The most striking feature of the Upper Ordovician section south of Georgian bay is the replacement of the bluish or greyish Kagawong limestones and shales by the soft, red Queenston clays. Towards Toronto even the lower or Eden part of the Lorraine shows lithological changes, with corresponding faunal differences.

LORRAINE-LIKE FORMATIONS

The only known continuous section of these strata near Meaford occurs about 3 miles southeast of the town along the lower part of Workman brook. The Collingwood black shale is not exposed, though it probably occurs in situ only a short distance below the level of the lake at this locality. Eastward, toward Field, it is well exposed along the shore. On Workman brook, *Cryptolithus bellulus* occurs 25 feet above the level of the lake. Farther up, thin limestones are interbedded with clay shale and contain the same bryozoan fauna as near Little Current. The road bridge crossing Workman brook rests on Lorraine-like strata that contain *Pholadomorpha*, especially upstream from the bridge. Both the Sheguiandah and the Wekwemikongsing phases of the Lorraine here closely resemble those on Manitoulin island.

Near Toronto, however, the lithological conditions are different, and the strata may be divided into a lower or Don River member and an upper or Humber River member, corresponding approximately to the Sheguiandah and Wekwemikongsing members of Manitoulin island and Georgian bay.

[1] "The Stratigraphy and Paleontology of the Cincinnati Series of Indiana," Geol. Nat. Res. Indiana, 32nd Ann. Rept., 1908, pp. 607-1189.

The Don River strata differ from the Sheguiandah in having limestones, interbedded in clay shale, which are much more argillaceous and less calcareous, resulting in a darker colour, the rock in many places weathering to a brownish tint. Among the species of bryozoans identified by Bassler from the Don Valley brick-yard, the following suggest Eden affinities: *Dekayella ulrichi*, *Bythopora arctipora*, and undescribed Eden forms of *Aspidopora*, *Chiloporella*, and *Stigmatella*. Among those occurring both in the Eden and in the Maysville are *Perenopora vera* and *Arthropora shafferi*. Among those hitherto cited by Bassler only from the Fairview division of the Maysville are *Atactopora maculata*, *Hallopora dalei* and *Hallopora subplana*. Of these, however, the two species of *Hallopora* are cited by Cumings and Galloway also from the upper or McMicken member of the Eden in the Tanner Creek section of Indiana, which means that only one species, *Atactopora maculata*, is peculiar to the Fairview. Clearly the evidence favours the reference of the Don Valley section to the Eden, preferably to the Southgate and McMicken members. This reference is supported by the presence of *Leptæna*, for this genus is known in the Nicolet River section only from strata apparently of Eden age, and, by the presence of *Cryptolithus*, for west of Toronto this genus is known only from beneath those strata that contain bryozoans apparently of Southgate age. Although *Cryptolithus* occurs in the Pulaski division in New York, it has not been identified from correspondingly high horizons elsewhere, and it has, apparently, a more restricted vertical range in Ontario.

The Humber River member includes the *Pholadomorpha* zone. From this horizon Bassler determined *Bythopora gracilis*, a typical Maysville species. It is especially abundant in the Bellevue member of Indiana, to which Ulrich assigns the *Pholadomorpha* zone of the Lorraine of New York.

MEAFORD OR WAYNESVILLE FORMATION

At Streetsville the Richmond formation includes, toward the top of the fossiliferous part, several horizons rich in large corals, including chiefly *Columnaria*, *Tetradium*, and *Stromatocerium*, but also *Calapoecia*. The total thickness of the coraliferous part equals 13 feet.

The total thickness of the Meaford at Streetsville is not known with certainty, but at least 60 feet of Richmond strata are exposed below the coral zone, and the total thickness may be nearer 90 feet. Judging from the Richmond exposures near Meaford, the *Hebertella insculpta* horizon forms the base of the richly fossiliferous part of the Waynesville, which in that area is 10 to 15 feet thick. No corresponding layers were found in the Streetsville area. Here the lower parts of the Richmond have a very Lorraine-like aspect, but the lowest strata referred definitely to the Richmond contain *Strophomena sulcata*, *S. planumbona*, and *Opisthoptera fissicosta*, in addition to *Pholadomorpha pholadiformis* and a species resembling *Modiolopsis concentrica*. The probability is that fossils suggesting Richmond age will be found at other localities in the upper part of these strata.

Judging from the exposures at Streetsville and on Humber river, the strata that contain *Pholadomorpha* associated with *Ischyrodonta* *unionoides* and *Orthodesma nasutum* belong to the Maysville and those that contain *Pholadomorpha* associated with *Strophomena* and *Opisthoptera* belong to the Richmond. Those that contain neither are of doubtful age.

QUEENSTON FORMATION

The Queenston red clay shales may be regarded as chiefly of Whitewater and Saluda age. In the Meaford area fossils are known only from a few horizons near the middle of the section, and include the ostracods *Drepanella canadensis, Eurychilina striatomarginata, Leperditia caecigena, Leperditella* cf. *glabra,* and *Primitia lativia,* associated with *Bythopora delicatula, Zygospira meafordensis, Pterinea demissa,* and two species of *Byssonychia.* Ulrich also found additional Richmond species at Oakville, north of lake Ontario.

At Streetsville the base of the Queenston shale rests on strata 17 feet thick, which overlie the rich coral zone. This zone is regarded by Ulrich as of Whitewater age, so that the base of the shale at Streetsville is regarded as starting above the base of the Whitewater.

At most other localities this base belongs apparently beneath the top of the Waynesville, it being assumed that the Liberty is absent in southern Ontario. West of the Disciples church, 6 miles north of Meaford, the Queenston directly overlies the richly fossiliferous part of the Waynesville, 14 feet thick. Farther north, on the eastern margin of lot 36 in concession VII, St. Vincent township, at least 20 feet of shaly rock intervenes between the richly fossiliferous part of the Waynesville and the beginning of the shale. At both localities the basal layers of the Queenston are regarded as belonging to the upper part of the Waynesville, but west of the Disciples church and at Oakville they include a greater thickness of upper Waynesville strata.

OTTAWA BASIN AND SOUTHERN QUEBEC

Northeast of the Frontenac axis, there is no evidence of close relationship of any of the Upper Ordovician strata to those of typical Cincinnatian areas. Nevertheless, some general ideas of probable equivalencies may be obtained.

In the Nicolet River section the Upper Ordovician strata present the following divisions, in descending order:

- Richmond formation
  - Queenston member, of Whitewater and Saluda age
  - Beds of Waynesville age, or *Strophomena* zone
- Lorraine formation
  - *Pholadomorpha* zone
  - *Proetus* zone
  - *Leptæna* zone
  - *Cryptolithus* zone

Cryptolithus has a vertical range of 800 feet associated with *Triarthrus* 100 feet below the top. In Cincinnatian areas *Triarthrus* does not range above the lower half of the Eden, where it is associated with *Cryptolithus.* The *Cryptolithus* zone of the Nicolet River section also is regarded as of lower Eden age, and this is confirmed by the presence of *Coeloclema com-*

mune, a characteristic Eden species, along Bécancour river, east of Breault. The character of the fauna appears to be similar from the lower part of the zone to the part above the *Triarthrus* layer, and the entire *Cryptolithus* zone is, therefore, correlated provisionally with the lower Eden.

Leptæna makes its first appearance 325 feet below the highest *Cryptolithus*. It has a vertical range of 1,060 feet. The presence of *Coeloclema commune* at several horizons in this *Leptæna* zone and the occurrence of *Dekayella ulrichi*, another characteristic Eden species, at its top, suggest that the *Leptæna* zone also is of Eden age.

Proetus chambliensis begins 180 feet beneath the top of the *Leptæna* zone, and has a total range of 370 feet. The presence in the *Proetus* zone along Nicolet river of *Dekayella ulrichi* indicates its Eden age. This is confirmed by the occurrence of *Bythopora arctipora*, another Eden species, in the *Proetus* zone at Chambly Canton. And, finally, a species of *Aspidopora*, in the *Proetus* zone both in the Nicolet River section and at Chambly Canton, is regarded by Ulrich as having affinities with an undescribed species in the Eden near Cincinnati.

Three entire zones, therefore, of the Lorraine, the *Cryptolithus*, *Leptæna*, and *Proetus*, represent the Eden of Cincinnatian areas.

The *Pholadomorpha* zone is merely the part of the Nicolet River section that lies above the highest Eden and the lowest Richmond. In Cincinnatian areas, the interval between the Eden and the Richmond is occupied by the Maysville formation; therefore, there is a possibility of the *Pholadomorpha* zone along Nicolet river being of Maysville age.

This possibility apparently finds support in the occurrence of *Pholadomorpha* in the upper part of the Pulaski in New York, where the associated fossils suggest the Maysville age of the Pulaski.

It must be admitted, however, that the absence of diagnostic fossils in the *Pholadomorpha* zone of Quebec makes its age determination difficult, and suggests the entire absence of the Maysville in that province in spite of the presence of large *Pterinea demissa* cited by Hall from the upper Pulaski of New York.

STROPHOMENA ZONE OR THE WAYNESVILLE MEMBER OF THE RICHMOND

In the Nicolet River section the lowest Richmond strata contain *S. planumbona* and a species resembling *Rhynchotrema perlamellosum* in its moderate gibbosity. The *S. planumbona* occurs again 15 and 60 feet farther up. *S. vetusta* and *S. sulcata* occur at several horizons between 65 and 75 feet above the base of this series. *S. hecuba* is found at several horizons between 70 and 100 feet above this base. *Platystrophia clarksvillensis* ranges from 60 to 70 feet above the base. One specimen of *Streptelasma rusticum* was found 95 feet above the base. A species of *Zygospira*, resembling *kentuckiensis* in being distinctly larger than *Z. modesta*, ranges from 130 to 155 feet above the base, and is very abundant in the upper layers assigned to the Richmond. The general assemblage of the fossils here listed indicates its Waynesville age.

In Cincinnatian areas the Waynesville shows the least change, lithologically and faunally, when traced into southern Ontario. The Canadian strata contain a much smaller number of species, and certain groups, such as the bryozoans and the pelecypods, are poorly represented. But most of the species are of Waynesville age, so that the wide distribution of this formation in southeastern Canada is one of the salient features of its Upper Ordovician geology. It should be noted, moreover, that the number of its species decreased when traced from the Manitoulin Island area east to the Toronto area, and continues to decrease when traced still farther eastward into the Ottawa basin and Quebec.

In the Waynesville zone of the Nicolet River section, *Pterinea demissa* and *Pholadomorpha pholadiformis* occur at different horizons from 95 to 125 feet above the base. Both species have an extended vertical range. In Cincinnatian areas *Catazyga headi* is known only from the Waynesville. In the Nicolet River section, however, it ranges from about 60 feet above the base of the Waynesville apparently to levels hundreds of feet below. Unless these lower occurrences prove to include a species different from *Catazyga headi* the value of this species in determining horizons remains in doubt. The Lorraine of New York contains a species, *Catazyga erratica*, readily discriminated from *C. headi*, but it has been impossible, along the Nicolet River section, to identify *Catazyga erratica* except at the top of the *Cryptolithus* zone, nearly 1,400 feet below the lowest Waynesville layers. The intermediate forms have not been discriminated from *Catazyga headi*.

RICHMOND OF LAKE ST. JOHN

On Snake island, at about lake level, only the rich coral zone is exposed. The underlying part of the Richmond is known only from slabs thrown up by the waves, and containing *Strophomena* resembling *S. sulcata* and *S. fluctuosa*, *Platystrophia clarksvillensis*, *Catazyga headi*, and *Rhombotrypa quadrata*. In the absence of any species later than the Waynesville, this part of the section is correlated with the Richmond.

The species in the overlying coral zone could occur in the Waynesville as well as in the Liberty or Whitewater. Owing to the presence of *Beatricea* it is regarded as of later than Waynesville age, but whether of Liberty, Whitewater, or Saluda age is uncertain. In the belief that the Liberty is entirely absent in southern Ontario and Quebec, this coral zone on Snake island is correlated with the Whitewater or Saluda. Whether the Queenston red clay shale ever extended so far east is unknown. The assumption that the rich coral zones on Snake island, at Streetsville, and on Manitoulin island are of about the same age is based on the fact that in all cases the underlying strata appear to be of Waynesville age. That it inaugurates a new division of the Richmond is surmised, but has not been proved definitely.

QUEENSTON MEMBER OF THE RICHMOND

South of the St. Lawrence the base of the Queenston shale rests on strata containing *Zygospira kentuckiensis*. No fossils suggesting later than the Waynesville age, ever are associated with this species. In fact, it is not unlikely that red clay sedimentation began in Queenston time before Waynesville sedimentation in typical Cincinnatian areas had ceased. Therefore, although almost the entire mass of Queenston shale is regarded as of Whitewater and Saluda age, its base may be upper Waynesville. Strictly speaking, the Queenston is merely a lithological designation, not an accurate time unit.

No fossils have been discovered so far in the Queenston shale of the Ottawa basin and Quebec.

CORRELATION OF UPPER ORDOVICIAN STRATA IN SOUTHERN ONTARIO AND QUEBEC WITH THE LORRAINE OF NEW YORK

To make this correlation intelligently, a better knowledge of the Lorraine of both areas is necessary, especially of that thick, lower part correlated with the Eden. In New York, this part consists almost entirely of dark shale which though lithologically looking quite homogeneous may prove faunally as complex as the typical Cincinnatian. Very little is known of the fauna of the Eden portion, the fauna of the Pulaski portion having, alone, received even moderate attention. The equivalency of lower Lorraine strata in Canada with lower Lorraine strata in New York cannot, therefore, be determined.

Among Canadian exposures, those along Humber river west of Weston bear the closest resemblance to the Pulaski of New York. Such species as *Pholadomorpha pholadiformis*, *Orthodesma nasutum*, *Ischyrodonta unionoides*, and *Pterinea demissa* suggest the Pulaski age of the Humber River exposures, especially of the upper part of the Pulaski, as exposed east of Worthville, in New York.

From the Humbervale quarry, also regarded as upper Pulaski, Miss Beatrice H. Stewart cites the following species:

Pholadomorpha pholadiformis	16-foot level
Byssonychia alveolata	16-foot level
Clidophorus fabulus	15-foot level
Ctenodonta myalta	15-foot level
Psiloconcha inornata	15-foot level
Orthodesma nasutum	10-foot level
Psiloconcha subrecta	10-foot level
Byssonychia vera	6-foot level
Byssonychia radiata	5-foot level

The Don Valley brick-yard section may, perhaps, be regarded as of earlier age than any part of the Pulaski section. The close resemblance of the species from this brick-yard to typical *Modiolopsis modiolaris*, one of the most characteristic species of the Pulaski, must be acknowledged.[1] But it is not certain that the species are identical. Compared with typical examples from New York, the upper posterior margin of the Don Valley specimen curves more gradually into the posterior part of the hinge-line. The anterior part of the shell is much more prolonged in front of the beak; its upper margin is more elevated and its ventral margin rises with a rather long oblique slope, so that the most rapidly rounded part of the anterior margin is distinctly more elevated. Finally, the angle between the dorsal and ventral margins is less. Apparently the Don Valley specimen represents a distinct species.

[1] "The Stratigraphy and Paleontology of Toronto and Vicinity," 29th Ann. Rept. Ontario Dept. of Mines, 29, pt. 6, 1920, pl. 3, fig. 1.

The *Ischyrodonta unionoides* figured by Miss Stewart from the same brick-yard also presents difficulties. Its height is much greater, the low umbonal ridge is less oblique, the shell is more produced anteriorly and shortened posteriorly, so that here also there is a probability of the Don Valley species being distinct.

Except in the Toronto area, no species in Ontario or Quebec is referable to *Orthodesma nasutum, Ischyrodonta unionoides,* or *Modiolopsis modiolaris.* Elsewhere the references to the Pulaski formation are based largely on the presence of *Pholadomorpha pholadiformis,* associated with numerous lamellibranchs, in the absence of species unquestionably of Richmond age.

The Oswego sandstone of New York (*See* Correlation table) is regarded as of upper Maysville or McMillan age. This correlation is based chiefly upon the gradual change of the underlying Pulaski shale into the Oswego sandstone section. No identifiable fossils are known from the Oswego at present.

From the preceding pages it is evident that the problems connected with the Upper Ordovician strata of Ontario and Quebec are many, and that only a few have been solved. If continuous exposures were numerous the field would be inviting. Unfortunately most exposures are so disconnected that the relative age even of exposures not far distant from each other frequently is in doubt.

The present volume is merely an attempt to collate the known facts for those interested or who may be investigating in the same field.

UPPER ORDOVICIAN CORRELATION TABLE

GENERAL TIME SCALE			Western New York	Central and Eastern New York	APPALACHIAN VALLEY: Penn. Md. and Va.	APPALACHIAN VALLEY: Tennessee	West Tennessee	OHIO VALLEY: West of Cincinnati	OHIO VALLEY: Southern Ohio & Eastern Ky.	Ontario	Iowa and Minnesota
UPPER ORDOVICIAN	RICHMOND	Elkhorn (Ind.)	Queenston shale		Juniata sandstone and shale	Sequatchie formation		Elkhorn (Belfast)			
		Whitewater (Ind.)						Versailles: Whitewater-Saluda (Madison and Fowler) (Kagawong in Manitoulin Islands)		Queenston	Ft. Atkinson ls.
		Maquoketa (Iowa)									Maquoketa shale
		Liberty (Ind.)						Laughery: Liberty			Clermont shale
		Waynesville (Ohio)	?					Waynesville {Blanchester member, Clarksville, Ft. Ancient}		Meaford	
		Fernvale (W.Tenn.)					Fernvale {Mannie sh., Leipers Cr. ls.}				Wykoff ls.
		Arnheim (Ohio)					Arnheim	Arnheim {Oregonia member, Sunset member}			
		Dubuque (Iowa)									Dubuque dol.
ORDOVICIAN (CINCINNATIAN)		Maysville	Oswego sandstone Pulaski formation	Oswego sandstone	Oswego sandstone (Bald Eagle)	Fairview	Leipers formation	Maysville formation			

ORDOVICIAN CORRELATION TABLE

GENERAL TIME SCALE				Central Pennsylvania	North central New York	Cincinnati dome	Nashville dome	Maryland basin	Arbuckle uplift (Oklahoma)	Arkansas: Northern	Arkansas: West central (Ouachitas)	Wisconsin Illinois	Minnesota and Northern Iowa	Manitoulin Ids. Lake Huron	Central Ontario	Esthonia, Russia
				Juniata		Richmond (Arnheim)			Fernvale	Fernvale	Fernvale	Fernvale	Dubuque dol.	Richmond	Richmond	Borkholm ls.(F²)
MIDDLE AND UPPER ORDOVICIAN	CINCINNATIAN	MAYSVILLE	McMillan (Ohio)	Oswego (Bald Eagle)	Lorraine: Oswego	McMillan: Mt. Auburn, Corryville (Gilbert), Bellevue (Tate)	Leipers (Swan Cr.)	Red ss.		Polk Bayou limestone				Wekwemikongsing	Humber River	
			Fairview (Ohio)	Shale	Pulaski	Fairview: Fairmount, Mt. Hope (Up. Garrard)										
		EDEN	Frankfort (N.Y.)		Frankfort sh. (Brayman)	Eden: McMicken (Paint lick), Southgate, Economy {Million}		Eden ss.						Sheguindah	Don River	
			Utica (N.Y.)		Utica	Fulton					Polk creek shale			Collingwood	Gloucester, Collingwood	
	MOHAWKIAN	TRENTON	Cynthiana (Ky.)	Trenton ls.; Reedsville shale	Upper Trenton ls.	Cynthiana {Rogers Gap, Gratz, Bromley, Greendale}	Nashville: Catheys f.	Martinsburg shale: Sandy shale	Viola limestone		Big fork chert	Galena dol.			Cobourg ls.	Lyckholm ls.(F¹)
			Perryville (Ky.)			Perryville {Cornishville, Faulconer}										
			Flanagan (Ky.)			Flanagan {Woodburn, Brannon}										
			Bigby (Ky.)		Middle Trenton ls.	Bigby (Paris in part)	Bigby {Capitol ls., Mt. Pleasant}	Black shale								Wesenberg ls.(E) Wassalem ls.(D^3) Kegel ls.(D^2)
			Wilmore (Ky.)			Wilmore ls							Stewartville dol. (Maclurea bed)		Middle Trenton	
			Hermitage (Ky.)	Lower Trenton limestone		Hermitage (Logana)	Hermitage ls. (Saltillo)	Shaly ls.								Jewe ls. (D^1)
			Curdsville (Ky.)		Lower Trenton ls.	Curdsville ls.	Curdsville						Prosser limestone	Prosser, Curdsville	Hull (Curdsville) Rockland ls. Glen Falls ls.	Itfer ls. (C^3)
		BLACK RIVER	Kimmswick (Mo.)					Upper Chambersburg		Kimmswick ls.						
			Decorah (Iowa)	Amsterdam ls.		Decorah sh. (Upper)			Bromide f.			Decorah shale {Upper Blue, Upper}		Cloche Island		Kuckers shale (C^2)
			Watertown (N.Y.)		Watertown ls.											
			Lowville (N.Y.)	Lowville ls.	Leray ls. Lowville ls.	Lowville {Leray ls, Tyrone ls, Oregon dol.}	Lowville (Carters)	Middle Chambersburg (Lowville)		Plattin ls.		Platteville {Lower Blue, Lower Buff, Glenwood shale}	Beloit ls.	Swift Current (Leray) Lowville	Leray ls. Lowville ls.	Echinospherites ls.(C^1)

PART II

DESCRIPTION OF SPECIES

LIST OF SPECIES DESCRIBED

Algae

Girvanella richmondensis (Miller)

Coelenterata

ANTHOZOA

Streptelasma rusticum (Billings)
Streptelasma dispandum Foerste
Streptelasma divaricans (Nicholson)
Columnaria alveolata Goldfuss
Columnaria calicina (Nicholson)
Lyopora goldfussi Billings

HYDROZOA

Calapoecia huronensis Billings
Tetradium huronense Foord
Protarea richmondensis Foerste
Protarea richmondensis papillata Foerste
Stromatocerium huronense (Billings)
Beatricea undulata Billings

Vermes

Cornulites sp.
Spirorbis cincinnatiensis Miller and Dyer
Burrow
Arthraria biclavata westonensis Foerste
Arthraria rogersensis Foerste
Licrophycus hudsonicum Billings

Echinodermata

ERIOASTEROIDEA

Cyclocystoides huronensis Billings

CRINOIDEA

Heterocrinus heterodactylus Hall
Heterocrinus juvenis Hall
Atyphocrinus corryvillensis Ulrich
Atyphocrinus juvenis (of Meek)
Isotomocrinus typus Ulrich
Dystactocrinus constrictus (Hall)
Ohiocrinus oehanus (Ulrich)
Ohiocrinus brauni Ulrich
Columbicrinus crassus (Ulrich)
Geraocrinus sculptus Ulrich
Homocrinus parvus Hall
Ectenocrinus simplex (Hall)
Drymocrinus geniculatus (Ulrich)
Daedalocrinus kirki Ulrich
Sygcaulocrinus typus Ulrich
Eustenocrinus springeri Ulrich
Drymocrinus manitoulinensis Foerste
Iocrinus subcrassus (Meek and Worthen)
Lichenocrinus obliquus Foerste
Compsocrinus harrissi (Miller)

STELLEROIDEA

Taeniaster meafordensis Foerste

Molluscoidea

BRYOZOA

Rhombotrypa quadrata (Rominger)
Constellaria polystomella Nicholson

BRACHIOPODA

Leptobolus insignis Hall
Lingula hyacinthensis Foerste
Lingula curta Conrad
Lingula rectilateralis Emmons
Trematis millepunctata Hall
Crania scabiosa Hall
Schizocrania filosa Hall
Pholidops subtruncata (Hall)
Pholidops cincinnatiensis Hall
Dalmanella sp. (Lorraine form)
Dalmanella manitoulinensis Foerste
Hebertella occidentalis (Hall)
Hebertella sinuata (Hall)
Glyptorthis insculpta (Hall)
Glyptorthis insculpta manitoulinensis Foerste
Glyptorthis crispata (Emmons)
Platystrophia clarksvillensis Foerste
Platystrophia versaillesensis Foerste
Plectambonites sericeus (Sowerby)
Plectambonites rugosus manitoulinensis Foerste
Plectambonites plicatellus (Ulrich)
Rafinesquina alternata (Emmons)
Rafinesquina nasuta (Conrad)
Rafinesquina mucronata Foerste
Leptæna moniquensis Foerste
Strophomena planumbona (Hall)
Strophomena manitoulinensis Foerste
Strophomena planumbona chambliensis Foerste
Strophomena planumbona gerontica Foerste
Strophomena nutans Meek
Strophomena huronensis Foerste
Strophomena fluctuosa Billings
Strophomena vetusta (James)
Strophomena neglecta (James)
Strophomena hecuba Billings
Holtedahlina sulcata (Verneuil)
Holtedahlina sulcata moniquensis Foerste
Holtedahlina varsensis Foerste
Rhynchotrema capax (Conrad)
Rhynchotrema increbescens (Hall)
Rhynchotrema perlamellosum (Whitfield)
Rhynchotrema pulchellum Foerste
Rhynchotrema (?) *tamarackensis* Foerste
Zygospira kentuckiensis James
Zygospira raymondi Foerste
Zygospira modesta (Hall)
Zygospira meafordensis Foerste
Catazyga headi (Billings)
Catazyga headi borealis (Billings)
Catazyga erratica (Hall)

Mollusca

PELECYPODA

Cuneamya neglecta (Meek)
Cuneamya scapha Hall and Whitfield
Cuneamya scapha brevior Foerste
Cuneamya elliptica Miller
Ctenodonta iphigenia Billings
Ctenodonta filistriata Ulrich
Ctenodonta albertina Ulrich
Ctenodonta simulatrix Ulrich
Ctenodonta madisonensis Ulrich
Ctenodonta myalta Stewart
Ctenodonta chambliensis Foerste
Ctenodonta hyacinthensis Foerste
Ctenodonta pectunculoides (Hall)
Ctenodonta lorrainensis Foerste
Ctenodonta borealis Foerste
Ctenodonta cingulata Ulrich
Ctenodonta cingulata gorensis Foerste
Clidophorus planulatus (Conrad)
Clidophorus tamarackensis Foerste
Clidophorus praevolutus Foerste
Clidophorus postvolutus Foerste
Clidophorus obliquus Stewart
Clidophorus neglectus Hall
Clidophorus brevis Foerste
Cyrtodonta ponderosa Billings
Cyrtodonta ponderosa perobliqua Foerste
Cyrtodonta ovalis Foerste
Cyrtodonta exigua Foerste
Cyrtodonta kagawongensis Foerste
Vanuxemia bayfieldi Billings
Vanuxemia kagawongensis Foerste
Ischyrodonta unionoides (Meek)
Ischyrodonta unionoides westonensis Foerste
Ischyrodonta curta (Conrad)
Ischyrodonta (?) *manitoulinensis* Foerste
Ortonella hainesi (Miller)
Ortonella stewarti Foerste
Ortonella (?) *gorensis* Foerste
Ortonella (?) sp. (Clay Cliff form)
Whitella securiformis Foerste
Whitella complanata Foerste
Whitella complanata moniquensis Foerste
Whitella obliquata Ulrich
Whitella hindi (Billings)
Whitella sterlingensis (Meek and Worthen)
Whitella torontonensis Stewart
Whitella goniumbonata Foerste
Whitella impressata Stewart
Whitella parksi Stewart
Whitella lata Stewart
Whitella acutiumbonis Stewart
Whitella radiata Stewart
Whitella huguesensis Foerste
Pterinea (*Caritodens*) *demissa* (Conrad)
Clionychia curta Foerste
Byssonychia vera Ulrich
Byssonychia vera hyacinthensis Foerste
Byssonychia vera plana Stewart
Byssonychia radiata Hall
Byssonychia borealis Foerste

Byssonychia suberecta Ulrich
Byssonychia grandis Ulrich
Byssonychia cultrata Ulrich
Byssonychia praecursa Ulrich
Byssonychia richmondensis Ulrich
Opisthoptera fissicosta (Meek)
Lyrodesma postplanum Foerste
Lyrodesma poststriatum (Emmons)
Lyrodesma poststriatum elongatum Stewart
Lyrodesma poststriatum manitoulinensis Foerste
Lyrodesma major Ulrich
Lyrodesma huguesensis Foerste
Colpomya cf. *constricta* Ulrich
Colpomya faba (Emmons)
Colpomya faba pusilla Foerste
Colpomya (?) sp. (Kagawong)
Cymatonota parallela (Hall)
Cymatonota pholadis (Conrad)
Cymatonota recta Ulrich
Cymatonota lenior Foerste
Cymatonota semistriata Ulrich
Modiolodon poststriatus Foerste
Modiolodon (?) *kagawongensis* Foerste
Modiolopsis hyacinthensis Foerste
Modiolopsis anodontoides (Emmons)
Modiolopsis borealis Foerste
Modiolopsis borealis postdeclivis Foerste
Modiolopsis meafordensis Foerste
Modiolopsis manitoulinensis Foerste
Modiolopsis concentrica Hall and Whitfield
Modiolopsis concentrica chambliensis Foerste
Modiolopsis vera Foerste
Modiolopsis brevantica Foerste
MODIOLOPSIS Hall (emend. Ulrich)
Modiolopsis ovata (Conrad), genotype
Modiolopsis milleri Ulrich
Modiolopsis valida Ulrich
Modiolopsis halli Ulrich
MODIODESMA Ulrich
Modiodesma modiolare (Conrad), genotype
Modiodesma modiolare angustifrons (Conrad)
Modiodesma modiolare brevior Ulrich
Modiodesma oblonga (Ulrich)
Modiodesma kentonensis (Ulrich)
Modiodesma scapha Ulrich
Modiodesma modiolare (Conrad)
Orthodesma (?) *postplicatum* (Foerste)
Orthodesma approximatum Foerste
Orthodesma canaliculatum Ulrich
Orthodesma canaliculatum consimilis Foerste
Orthodesma prolatum Foerste
Orthodesma pulaskiense Foerste
Orthodesma nasutum (Conrad)
Psiloconcha inornata Ulrich
Psiloconcha subovalis Ulrich
Psiloconcha sinuata Ulrich
Psiloconcha borealis Foerste
Pholadomorpha pholadiformis (Hall)
Pholadomorpha divaricata Hall and Whitfield
Pholadomorpha chambliensis Foerste
Rhytimya compressa Ulrich
Rhytimya colemani Stewart
Rhytimya oehana Ulrich

Rhytimya radiata Ulrich
Rhytimya granulosa Wilson
Rhytimya kagawongensis Foerste
Conocardium richmondense Foerste

GASTROPODA

Archinacella richmondensis Ulrich
Archinacella kagawongensis Foerste
Archinacella laevis Foerste
Archinacella pulaskiensis Foerste
Vallatotheca manitoulinensis Foerste
Cyrtolites ornatus Conrad
Cyrtolites subplanus Ulrich
Cyrtolites parvus Ulrich
Cyrtolites carinatus Miller
Sinuites cancellatus (Hall)
Oxydiscus perstriatus Foerste
Oxydiscus subacutus Ulrich
Salpingostoma richmondensis Ulrich
Salpingostoma (?) *lata* Foerste
Bellerophon mohri Miller
Bellerophon parksi Foerste
Liospira micula (Hall)
Liospira helena (Billings)
Eotomaria canalifera Ulrich
Eotomaria remotistriata Foerste
Clathrospira subconica (Hall)
Lophospira (?) *hyacinthensis* Foerste
Lophospira belli Foerste
Lophospira obliqua Ulrich and Scofield
Lophospira laticarinata Foerste
Lophospira elevata Ulrich and Scofield
Lophospira tropidophora (Meek)
Lophospira manitoulinensis Foerste
Lophospira sumnerensis (Safford)
Lophospira bowdeni (Safford)
Lophospira beatrice Foerste
Lophospira kindlei Foerste
Lophospira notabilis Ulrich
Hormotoma gracilis angustata (Hall)
Hormotoma gracilis sublaxa Ulrich
Helicotoma brocki Foerste
Helicotoma planulata Salter
Helicotoma planulatoides Ulrich
Cyclonema bilix conicum Miller
Holopea nicolettensis Foerste
Holopea insignis Ulrich and Scofield
Pterotheca clochensis Foerste
Pterotheca harviei Foerste
Pterotheca pentagona Foerste

CEPHALOPODA

Endoceras sp.
Billingsites manitoulinensis Foerste
Billingsites newberryi (Billings)
Spyroceras chambliense Foerste
Spyroceras hammelli Foerste
Spyroceras parksi Foerste
Sactoceras piso Billings
Sactoceras manitoulinense Foerste
Sactoceras westonense Foerste
Sactoceras (?) sp.

Kindleoceras reversatum Foerste
Kindleoceras triangulare Foerste
Actinoceras (?) *lambei* Foerste
Cyrtorizcceras ligarius Billings
Manitoulinoceras lysander (Billings)
Manitoulinoceras postumius Billings
Zitteloceras hitzi Foerste
Oncoceras pauper Foerste

Arthropoda

TRILOBITA

Cryptolithus tesselatus Green
Cryptolithus sp. (Montmorency Falls)
Cryptolithus lorettensis Foerste
Cryptolithus bellulus (Ulrich)
Cryptolithus recurvus Ulrich
Triarthrus becki Green
Triarthrus eatoni (Hall)
Triarthrus huguesensis Foerste
Isotelus gigas DeKay
Isotelus megistos Locke
Isotelus maximus Locke
Homotelus stegops (Green)
Proetus chambliensis Foerste
Odontopleura sp.
Calymene senaria Conrad
Calymene conradi Emmons
Calymene granulosa Foerste
Calymene meeki Foerste
Calymene callicephala Green
Calymene retrorsa Foerste
Calymene retrorsa minuens Foerste
Calymene sp. (Toronto)
Ceraurinus marginatus Barton
Ceraurinus icarus (Billings)
Technophorus quincuncialis Foerste

OSTRACODA

Leperditia caecigena Miller
Leperditia manitoulinensis Foerste
Leperditella (?) *glabra* Ulrich
Ceratopsis oculifera (Hall)
Ctenobolbina ciliata (Emmons)
Drepanella richardsoni canadensis Ulrich
Eurychilina (?) *striatomarginata* (Miller)
Jonesella crepidiformis (Ulrich)
Primitia centralis Ulrich
Primitia lativia Ulrich
Bythocypris cylindrica (Hall)
Lepidocoleus jamesi Hall and Whitfield

Girvanella richmondensis (Miller)[1]
Plate II, Figure 3

Stromatocerium richmondense Miller, Jour. Cincinnati Soc. Nat. Hist., 5, 1882, p. 41, pl. 2, figs. 1, 1*a*, 1*b*.
Girvanella richmondense James, J. F., ibid., 14, pt. 1, 1891, p. 51.

Small, irregular, more or less globular masses, usually 10 to 15 mm. in diameter. Strongly weathered specimens show concentric laminæ and, perpendicular to the laminæ, a very fine, fibrous structure discernible only under a lens. From 15 to 20 fibres, in width of 1 mm.

Described originally from the Whitewater member of the Richmond at Richmond, Ind. Rather widely distributed at this horizon in southeastern Indiana and adjacent parts of Ohio. At Madison, Ind., a similar species occurs in the upper part of the Bellevue member of the Maysville. Specimens occur also at the *Orthorhynchula linneyi* horizon in the upper part of the Fairmount member of the Maysville, about 3 miles east of Shelby City, central Kentucky.

American species of *Girvanella* are chiefly of Chazyan age, occurring in Vermont, New York, and east Tennessee. *Girvanella* is regarded at present as one of the lime secreting filamentous algae.

Locality and Horizon. From the Richmond, 2 miles northeast of Gore Bay, 25 feet above the lake north of Manitowaning, 2 miles southwest of Wekwemikong, and at Clay cliffs. It occurs also in the Whitewater member of the Richmond south of Reynold Point on Drummond island, and on Bay de Noc peninsula, east of Escanaba, Michigan.

Streptelasma rusticum (Billings)
Plate I, Figures 1 *a*, *b*, *c*, 2 *a*, *b*, *c*; Plate II, Figure 6 *a*, *b*, *c*

Petraia rustica Billings, Canadian Nat. Geol., 3, 1858, p. 422.
Streptelasma rusticum Lambe, Contr. Canadian Pal., Geol. Surv., Can., 4, pt. 2, 1901, p. 110, pl. 7, figs. 2, 2*a*, 3.
Streptelasma vagans Foerste, Bull. Sci. Lab. Denison Univ., 14, 1909, p. 305, pl. 11, figs. 1 *a-c*.

Streptelasma rusticum was described by Billings from Snake island, where loose specimens are thrown up in great numbers by the waves from some stratum below water-level. Since the exposures at water-level here include great numbers of *Columnaria*, *Calapoecia*, *Lyopora*, and *Stromatocerium*, corals which at Streetsville and on Manitoulin island are abundant at the top of the Waynesville member of the Richmond formation, the types of *Streptelasma rusticum* probably also came from the Waynesville.

The Snake Island specimens are chiefly small, comparatively few specimens exceeding 65 mm. in length. Most specimens from Snake island agree fairly well with Billing's description in being straight or slightly curved. Specimens more strongly curved toward the base comparatively rare; number of septa varying from 82 to about 100 in specimens examined, alternating in size, only the larger septa reaching the twisted, confused area at centre of calyx.

[1] Numbers of specimens refer to the catalogue of the Geological Survey, Canada.

Lambe,[1] figures a specimen 78 mm. long, 22 mm. wide at the top, and remarkably straight, but this specimen is very abnormal. Usually a specimen of this length has a width of at least 25 mm. and is curved lengthwise.

Under the name *Petraia Canadensis* Billings[2] figures a species of *Streptelasma* from the northern margin of Drummond island. There, as on Snake island, the coral horizon containing *Columnaria* and *Calapoecia* is abundantly represented, and numerous specimens of *Streptelasma* occur both at this horizon and in underlying strata. Specimens vary in length, diameter, and amount of curvature; some curved in lower half and straight in upper half; expanding to a width of 25 to 40 mm. in a length of 75 to 100 mm. This species was supposed by Billings to differ from *S. rusticum* in having shorter septa and a flat or convex bottom in the calyx. *Petraia canadensis* and *S. rusticum,* as pointed out by Lambe, belong to the same species. Specimens No. 8527, Snake island; No. 8528, comparatively straight forms, Clay cliffs; No. 8529, more strongly curved forms, same locality; No. 8530, both straight and curved forms, gully north of lighthouse at Manitowaning; No. 8531, hill-side west of Cape Rich road, 7 miles north of Meaford.

Streptelasma rusticum, very abundant at Clay cliffs; varies from nearly straight to strongly curved along lower half, all specimens being nearly straight toward the top. The majority of specimens are not more than 60 to 65 mm. long, but some are 80 mm. and some even 100 mm.

Areas of attachment of *Streptelasma rusticum* mostly so small as to suggest that they could not have served except during early stages of growth of the coral. Specimens No. 8573 show these attachment areas. The range of *Streptelasma rusticum* practically the geographical extent of the Richmond formation in Canada and the United States.

Locality and Horizon. Richmond from Snake island, Nicolet River section, St. Hugues, St. Hilaire; Manitoulin island where it occurs at every locality exposing the lower and middle parts of the Richmond, but is absent or rare in upper parts. At Streetsville, specimens of *Streptelasma,* only a quarter of an inch long, are very rare, and may belong to another species.

Streptelasma dispandum Foerste
Plate II, Figure 4

Streptelasma dispandum Foerste, Bull. Sci. Lab. Denison Univ., 14, 1909, p. 307, pl. 9, figs. 4 *a, b.*

In Ohio and Indiana, those specimens of *Streptelasma* which occur in the Blanchester division of the Waynesville member tend to be robust, expanding more rapidly than typical *S. rusticum*—this rapid expansion conspicuous, especially in the young. Older specimens tend to form large calyces; as a rule strongly curved, though relatively straight forms also occur.

Locality and Horizon. Specimens (No. 8532) similar in form occur at the *Columnaria* horizon, and in immediately overlying strata in the

[1] "Revision of the Genera and Species of Canadian Palæozoic Corals," Cont. Canadian Pal., Geol. Surv., Can., 4, pt. 2, 1901, p. 110, pl. 7, figs. 2, 2a.
[2] "Geology of Canada, 1863," Geol. Surv., Can., p. 208, Fig. 205.

open field south of the road, southwest from the McLean Hill exposures; 3 miles southwest of Little Current; south of Kagawong; and on the west side of Gore bay.

Streptelasma divaricans (Nicholson)
Plate II, Figure 5 *a, b, c, d*

Palæophyllum divaricans Nicholson, Geol. Surv., Ohio, Pal. 2, 1875, p. 220, pl. 22, figs. 10, 10 *a*, 10 *b*.
Streptelasma divaricans Foerste, Bull. Sci. Lab. Denison Univ., 14, 1909, p. 307, pl. 10, figs. 4 *a-e*.

In the Whitewater member of the Richmond of Ohio, Indiana, and Kentucky, is a small species of *Streptelasma*, mostly 12 to 20 mm. long, which tends to grow in clusters, and with its base spreading over a relatively large attachment area. The small specimens of *Streptelasma* in the Liberty member of the Richmond may belong to another species. Usually their area of attachment is much more oblique, and the corals do not rise far above their support. Small *Streptelasma* at the Coral horizon of Snake island resembles *S. divaricans*, but cannot be referred definitely to this species.

When many *S. divaricans* are attached to the same support, they tend to be parallel, as though rising vertically from their attachment areas.

In the Liberty, near Clarksville, Ohio, is an undescribed form of *Streptelasma*, rarely exceeding 10 mm. in length, attached along its cardinal side very obliquely for half or almost all its length, similar to *S. parasiticum*, described by Ulrich from the Platteville and Decorah members of the Black River formation in Minnesota.

Columnaria alveolata Goldfuss
Plate IV, Figure 4; Plate V, Figures 1, 2

Columnaria alveolata Goldfuss, Petrefacta Germaniæ, 1, 1826, p. 72, pl. 24, figs. 7 *a-c;* 2nd ed., pt. 1, 1862, p. 68.
Columnaria alveolata Foerste, Bull. Sci. Lab. Denison Univ., 14, 1909, p. 312, pl. 11, fig. 3.

Readily recognized by its conspicuous septa, half of which reach, or nearly reach, the centre of the corallites. Corallites usually about 4 mm. in diameter, but varying from 2 to 6 mm. Their outlines as a rule polygonal, owing to contact with one another on all sides. Horizontal tabulæ present.

The type of this species was stated by Goldfuss to have been obtained from near Seneca lake, New York. It must have come from an erratic boulder, probably of Black River age, for *Columnaria* does not again occur in New York or north of it until the Richmond, and no Richmond locality is known from which a specimen could have been brought by glacial action to the Seneca Lake region. The two nearest Richmond exposures containing *Columnaria* are at Streetsville, and on Snake island.

Columnaria multiradiata Castelnau[1] was the first name proposed for a Richmond representative of this species, from the north shore of Drum-

[1] Essai Syst. Sil. Amer. Sept., 1843, p. 44, pl. 19, fig. 1.

mond island. *Favistella stellata* Hall was the second name proposed for a Richmond species; described from the base of the Saluda at Madison, Ind.[1] Later, the names *Columnaria blainvilli* and *Columnaria rigida* were proposed by Billings for Richmond representatives on Snake island.[2] In *C. blainville* (Plate V, fig. 2), the corallites average about 3 mm. in diameter; septa conspicuous and almost or quite reaching the centre, from 6 to 8 tabulæ occurring in a length of 10 mm. In *Columnaria rigida* (Plate V, fig. 1); the corallites mostly larger, frequently attaining a diameter of 4 or 5 mm.; the septa from 7 to 8 in a length of 10 mm., as a rule short, but some reaching the centre. Their failure in some cases to do so may be due to poor preservation, judging from the corallites in which the centre is reached.

The Richmond representatives have not been clearly differentiated from the Black River forms.

Locality and Horizon. In Canada, Richmond representatives of *C. alveolata* occur on Snake island; at Streetsville; at Oakville (one specimen); and Meaford. On Manitoulin island it is relatively common at the top of the Meaford member. *C. alveolata* is widely distributed in the Richmond of Ohio, Indiana, and Kentucky. At Clifton, Tennessee, several specimens were found in the Arnheim member of the Richmond. From the western part of Henry county to the northwestern edge of Nelson county, in Kentucky, it is common locally in the lower part of the Waynesville member. From Jefferson county to the middle of Casey county, in Kentucky, it is common in the lower part of the Liberty member. From about 20 miles south of Madison, Indiana, to 2 miles northeast of Osgood, it is common in the lower part of the Saluda. It is common in the Whitewater member of the R chmond on Drummond island, but relatively rare on the Bay de Noc peninsula in northern Michigan. At the latter locality a small-celled species, resembling *Paleofavosites asper* D'Orbigny, is relatively common, associated with *Palaeophyllum stokesi* (Edwards and Haime) and *Halysites gracilis* (Hall).

Columnaria calicina (Nicholson)

Plate IV, Figure 3 *a*, *b*

Favistella (Columnaria) *calicina* Nicholson, Rep. 44th Meeting Brit. Assoc. Adv. Sci., Notes and Abstracts, 1874, p. 89.
Columnaria herzeri Rominger, Geol. Surv. Michigan, 3, pt. 2, 1876, p. 91.

Columnaria calicina represents merely some pathological condition of *C. alveolata* in which, for some unknown reason, some parts of the corallum do not bud sufficiently to cause the corallites to crowd each other. When the walls of the corallites can develop freely they become cylindrical rather than polygonal. Apparently this takes place most frequently where sudden influxes of mud or fine sand interfere with the growth of the corallum.

C. herzeri is a name given by Rominger to a similar pathological condition in specimens of *C. alveolata* found by Rev. H. Herzer, east of Louisville. Such specimens are not uncommon in the richly fossiliferous

[1] Pal. New York, 1, 1847, p. 275, pl. 75, figs. 1 a-c.
[2] Canadian Nat. Geol., 3, 1858, p. 421.

horizons immediately below the Saluda in Oldham, Jefferson, Bullit, and Nelson counties, Kentucky, but only where the enclosing limestone is very argillaceous.

C. alveolata discreta Foerste, from the Black River on Cloche island, represents a similar pathological condition with discrete corallites.

Locality and Horizon. The type of *C. calicina* (Coral zone of the Kagawong) was described by Nicholson from near Streetsville, where similar forms are common on Credit river. Similar specimens occur at Clay cliffs and westward. Also in the Whitewater member of the Richmond on Drummond island.

Lyopora goldfussi Billings

Plate III, Figure 1

Columnaria goldfussi Billings, Canadian Nat. Geol., 3, 1858, p. 420.
Lyopora Goldfussi Lambe, Cont. Can. Pal., Geol. Surv., Can., 4, pt. 1, 1899, p. 88, pl. 5, figs. 6, 6*a*, 7.

Coralla form approximately globular masses, sometimes 15 cm. in diameter, larger specimens tending to become semilobate, lobes usually not exceeding 20 mm. in height; corallites mostly have circular cross-sections, owing to their failure to crowd each other at the angles, diameter of the corallites from 1 to 2 mm., septa represented by 12 vertical ridges extending only a short distance from the walls, inward, number of horizontal tabulæ in a length of 2 mm. usually from 4 to 6. They tend to curve so as to appear concave when viewed from above. Similar transverse laminæ apparently occur also in the angular spaces between the corallites.

Locality and Horizon. The types of *Lyopora goldfussi* were obtained from Snake island and Traverse point. It occurs in the Vaurial member of the Richmond, Anticosti island. It is listed by Lambe from Clay cliffs. The Lake St. John and Manitoulin Island localities belong to the Richmond. *Lyopora* occurs both in the Coral zone and in the underlying Waynesville.

In Ohio, *Lyopora goldfussi* occurs in the Waynesville at Oregonia, but specimens are small and scarce.

Specimen No. 1764, from Snake island.

Calapoecia huronensis Billings

Plate IV, Figure 2

Calapoecia huronensis Billings, Canadian Nat. Geol., n.s., 2, 1865, p. 426.
Columnopora cribiformis Nicholson, Geol. Mag., Dec. 2, 1, 1874, p. 253, figs. 1 *a-c*.
Houghtonia huronica Rominger, Geol. Surv. Michigan, 3, pt. 2, 1876, p. 18, pl. 3, figs. 3, 4.

Corallum nearly globular, many 10 cm. and some 20 cm. in diameter, corallites presenting circular outlines, usually 2 to 3 mm. in diameter, separated by spaces of varying width, mostly permitting tangential contact between the circular walls, but in some places widening to spaces equalling half the diameter of the corallites. Around the margin of the calyces the surface of the corallum as a rule somewhat crenulated or denticulated; angular spaces between the circular corallites filled by a sort of coenenchym; interior of the corallites lined by about twenty narrow, vertical septal ridges; transverse tabulæ present in some specimens, but absent in most, undoubtedly owing to lack of preservation; walls of the corallites penetrated by numerous pores tending to be arranged, approximately, in vertical and horizontal rows, forming a sort of lattice-work, spaces between the corallites occupied by irregular horizontal diaphragms.

Calapoecia huronensis was described by Billings from the Richmond exposures at Clay cliffs. There, and elsewhere on the island it is fairly abundant and possesses the characteristics noted above.

Columnopora cribriformis, described by Nicholson, was obtained from near the bridge crossing Credit river at the western end of Streetsville. This type was lost in the fire that destroyed the Toronto University museum. In the upper Waynesville of Ohio, occasional specimens occur and range as far up as the Whitewater and Saluda. From some unknown locality in this state U. P. James found a single small specimen referred by Nicholson[1] to this species, and numbered 216 in the James collection at the University of Chicago.

Houghtonia huronica was described by Rominger from the Richmond on the north shore of Drummond island.

Calapoecia huronensis, *Columnopora cribriformis*, and *Houghtonia huronica* are definitely known from numerous specimens from the type localities.

It is possible that even the *Protarea verneuili* of Edwards and Haime, from the "Lower Silurian" at Alexandersville, Ohio, was a *Calapoecia*, since the Liberty and overlying strata are exposed there, and such depauperate specimens as those collected by James are found in the Liberty of Ohio. At any rate, it is the only species known that even approximately corresponds to the description of that form, especially the following part: "une vingtaine de cloisons peu inegales, assez minces; largeur des calices 3 millimetres."[2]

All the Richmond forms of *Calapoecia* from Ontario, listed above, are regarded by Lambe as identical with *C. canadensis* Billings from the Black River strata at Paquette rapids near Ottawa and *C. anticostiensis* Billings from the English Head, Vaurial, and Ellis Bay members of the Richmond on Anticosti island.[3] The Richmond forms are closely similar to those from the Black River, but the Black River forms examined by the writer have the pores more evidently arranged in transverse rows; the denticulations at the free margins of the septal ridges, along the upper margin of the calyces, are more pronounced, and the horizontal tabulæ are mostly more regularly disposed. The type of *C. anticostiensis* from the Richmond of Anticosti, presents a different appearance, especially the surface of the specimen, where the space between the corallites is occupied by a membranous layer depressed distinctly below the margin of the corallites. Billings refers to the "costæ forming a fringe around the apertures," and his vertical polished section indicates a more pronounced lamellar struc-

[1] "Palæontology of Ohio," 2, 1875, Pl. 22.
[2] Mon. d. Pol. Foss. d. Terr. Pal., 1851, p. 209.
[3] Canadian Nat. Geol., n.s., 2, 1865, p. 426.

ture between the corallites than in the Richmond forms farther west. Although, therefore, the identity of the Richmond forms from Ontario with those from Anticosti is probable, it is not regarded as proved.

Unfortunately Lambe did not figure the type of *C. canadensis* or *C. anticostiensis*, but used a specimen from the Galena-Trenton at Lower Fort Garry, and the exact age of specimens referred to the Galena-Trenton of Manitoba area is doubtful.

Calapoecia huronensis is widely distributed in Ohio, Indiana, and Kentucky, occurring as far south as Marion county. It is very common at the coral zones along the western side of the Cincinnati geanticline, in Indiana and Kentucky, especially in the lower Saluda and lower Liberty members.

Locality and Horizon. Found on Manitoulin island, wherever the Meaford and the immediately overlying strata are exposed; north of Meaford; at Streetsville; and on Snake island. On Drummond island *Calapoecia* occurs in strata equivalent to the Whitewater member of the Richmond. It occurs at similar horizons east of Escanaba, Michigan.

Tetradium huronense Foord

Plate IV, Figure 1 *a*, *b*

Stenopora huronensis Billings, Geol. Surv., Can., Pal. Foss., 1, 1865, p. 185.

Tetradium huronense Foord, Contributions to Micro-Paleontology of Cambro-Silurian Rocks of Canada, 1883, p. 25, pl. 7, figs. 1 *b-e*.

Tetradium Ontario Hall, 35th Rept. New York State Mus. Nat. Hist., 1884, pl. 16, fig. 9 (Figured and named, but not described).

Tetradium approximatum Ulrich, Amer. Geol., 1, 1888, p. 183 (Nomen nudum).

Tetradium approximatum Bassler, Bibl. Index Amer. Ord. Sil. Fossils, Bull. 92, 2, 1915, U.S. Nat. Mus., p. 1264 (Numerous citations of descriptions and figures).

Corallum massive, mostly irregularly hemispherical or subglobular, frequently attaining a diameter of 15 cm., some exceeding even 30 cm. Composed of numerous very narrow diverging corallites, which in vertical sections have a fibrous appearance. Corallites are more or less four-sided, with a vertical septal ridge along median line of each of the sides. In spite of these quadrangular outlines, the corallites, owing to crowding, may be described more accurately as irregularly polygonal; frequently small groups will present rather distinctly quadrangular outlines, but, where these groups meet, outlines irregular, suggesting that corallites within the same small group have a common point of origin. In by far the larger number of corallites the septal ridges appear in cross-sections as mere denticulations, extending only a short distance inward from the corallite wall. Only at points where fission takes place do the septal ridges extend farther into the interior, finally meeting at the centre, and thus starting a new series of corallites. Average diameter of full-grown corallites 1 mm. or a little less, many only 0·6 mm. in diameter, and a few, shortly before fission takes place, reaching a diameter of $1\frac{1}{2}$ mm. Usually 4 to 6, in some places only 3, tabulæ occur in a length of 2 mm. The nomenclature of this species presents some difficulties.

Stenopora huronensis Billings was described from the Richmond at Clay cliffs. The type consists of a *Tetradium* overgrown by *Stromatocerium.* The description by Billings shows that he failed to distinguish between these two species, but, as his description refers mainly to the *Stromatocerium,* he is credited with *S. huronense.*

When Foord studied Billing's type by means of microscopic sections, he at once recognized that the interior of this specimen belonged to the genus *Tetradium,* but he, also, failed to distinguish the remainder of the specimen, the *Stromatocerium,* as belonging to a different organism. Foord's description is based mainly on the *Tetradium* part of this specimen, which should be known as *Tetradium huronense* Foord.

A year later than Foord, Hall figured a specimen of *Tetradium* under the name *T. ontario,* accompaning the figure by the legend: "An horizontal section showing the form of the tubules in a very satisfactory manner. Clinton group, shore of lake Ontario." To any one familiar with the geology of the Lake Ontario region it is evident that this specimen came from the base of the red Queenston shale. The type was an erratic specimen from near Hamilton. Other specimens, with reddish stains, have been found as far east as Oakville and Streetsville. It was this red stain that suggested to Hall the Clinton derivation of his type. His species was figured, but not described.

Several years later Ulrich used the name *Tetradium approximatum,* without any description or figure, in a list of fossils from his Bed XIII. In this list he included fossils as low as *Dinorthis retrorsa* (= *carleyi*) from the Arnheim, and as far up as *D. subquadrata* and *Strophomena vetusta,* in the Liberty. His Bed XIV included Whitewater species. Whether only one species of *Tetradium* is represented in the long range between the Arnheim and the Liberty is still doubtful.

Bassler cites *T. approximatum* from the Richmond, without giving any more definite horizon. Whatever value this name may have dates from the publication of Bassler's Bibliographic Index.

T. ontario unquestionably is the same species as *T. huronense,* both coming from the Waynesville and from the overlying Coral horizon. The writer cannot distinguish this Canadian species from the *Tetradium* so common at the base of the Saluda in Indiana and Kentucky and in the Liberty of those states, to which Ulrich applied the name *T. approximatum,* but without either figure or de cription.

In the *Orthoceras fosteri* zone at the base of the Clarksville division occurs a large flat form of *Tetradium,* 30 cm. or more in diameter, and only 5 to 10 cm. in height, which may belong to a distinct species.

Tetradium makes its first appearance in the Chazyan. One of the simplest species is *T. cylindricum* Wilson, described from the Aylmer limestone at MacLaren Landing, west of Ottawa. *T. syringoporoides* Ulrich is a Stones River form from Pennsylvania, Maryland, and Virginia. Although as a rule classed as a coral, the true relations of *Tetradium* may be nearer to the *Bryozoa* than ordinarily supposed.

Locality and Horizon. Widely distributed in Manitoulin island as far west as Gore Bay and on Barrie island. North of Meaford it occurs on the Cape Rich road. At Oakville a single specimen was found directly beneath the red Queenston clay shale. At Streetsville it is common at the great Coral horizon. It occurs in abundance also on Snake island. At all these localities its range is from the Waynesville for some distance above the overlying Coral horizon. On Drummond island it occurs south of Reynold Point in the Whitewater member of the Richmond.

Protarea richmondensis Foerste
Plate I, Figure 4

Protarea richmondensis Foerste, Bull. Denison Univ., 14, 1909, p. 210; p. 308, pl. 7, fig. 8.

Thin papillate stroma with about four shallow, rounded depressions or calyces in a width of 5 mm., papillæ along the walls of these depressions tending to radiate inward for a short distance like septa, and in typical forms of this species fairly distinct and about twelve in number. Specimens originate as a thin papillate stroma covering the surface of some shell or other solid support. As this stroma grows thicker, some of the papillæ increase in height around central areas of depression, or calyces; these areas of depression approximately of the same diameter and depth, both the depressions and the intervening spaces papillate, the papillæ being coarser on the spaces between the calyces. Only the thicker specimens show a tendency toward the arrangement of the papillæ along septal lines, but even the thickest of these rarely attain 3 mm. No intermediate tubules with transverse disseppiments known in this species, such as those figured by Lambe for *Protarea vetusta* (Hall). The genotype of *Protarea* is not *P. vetusta* (Hall) from the Trenton of New York, but the Richmond form here called *P. richmondensis*, as may be seen from the figures presented by Edwards and Haime.[1]

In Ohio, Indiana, and Kentucky, *P. richmondensis* ranges from the base of the Clarksville to the top of the Whitewater, where the type was secured. This species is known also from the Richmond in Tennessee, Illinois, Minnesota, and other western localities. The writer has never seen *P. vetusta*, from the Trenton and Black River of New York and Canada, in the form of thin incrustations on other bodies, but it must have grown on something. The latter occurs in much thicker growths, 10 to 20 mm. thick, built up from a succession of lamellar expansions, many of them partly separated by argillaceous material, a feature unknown in the Richmond species. The spaces between the corallites are occupied by a massive substance in which Lambe detected minute tubules crossed by dissepiments. The septa, in cross-sections, are clearly defined. The species was described from the lower Trenton, near its junction with the Black River limestone, at Watertown, New York, but excellent specimens occur also in the Trenton at Nepean point (Ottawa) and elsewhere in Ontario.

Locality and Horizon. Found on the west side of Gore bay (No. 8535) and at Clay cliffs in the Meaford. Also in the Whitewater member of the Richmond on Drummond island, and on Bay de Noc peninsula, northern Michigan.

[1] Mon. d. Polyp. Foss. d. Terr. Pal. published in Archiv. du. Mus. d'Hist. Nat., 5, in 1851, p. 208, pl. 14, figs. 6, 6a.

Protarea richmondensis papillata Foerste
Plate I, Figure 3 *a, b*

Protarea richmondensis papillata Foerste, Bull. Denison Univ., 14, 1909, p. 309, pl. 10, fig. 2.

This form differs from typical *Protarea richmondensis* in lacking any definite suggestion of septa. It would be regarded merely as a young stage of the latter were it not that the papillæ become coarser and more widely spaced.

P. richmondensis papillata starts its growth like a species of *Dermatostroma*. A thin layer with a coarsely granulate surface covers part of the supporting body. The granules are somewhat irregularly arranged. As the layer thickens, depressions subequal in size, appear on its surface, but no radiating septa; on the contrary, irregularly arranged granules cover all parts of the surface, but are a little more prominent on the margins of the depressions. When there is an appearance suggesting septa in thick layers, the specimens are referred to *P. richmondensis*. Even when structures like septa appear, traces of the original granular appearance abound. *Protarea richmondensis* and its variety *papillata* probably are hydrozoa, related to *Dermatostroma*, and are not true corals.

Locality and Horizon. Found on the west side of Gore bay (No. 8534); northwest of Kagawong; and at Clay cliffs (No. 8533). At these localities the variety papillata is more common than the typical forms of *P. richmondensis*.

In the United States, the variety *papillata* has about the same vertical and geographical range as the typical forms of *P. richmondensis*. The type of the variety was secured from the Whitewater member at Dayton, Ohio.

Stromatocerium huronense (Billings)
Plate II, Figure 2; Plate III, Figure 2

Stenopora huronensis Billings, Geol. Surv., Can., Pal. Foss., 1, 1865, p. 185.
Alveolites granulosus James, Cat. Foss. Cincinnati Group, 1875, p. 2.
Labechia ohioensis Nicholson, Mon. British Strom., 1885, p. 32, pl. 1, figs. 1, 2, footnote.
Stromatopora indianensis James, Jour. Cincinnati Soc. Nat. Hist., 15, pt. 3, 1892, p. 92.
Cf. *Labechia montifera* Ulrich, Contr. to Amer. Pal., 1, p. 33, fig.; also pl. 2, figs. 9, 9*a*, from a different specimen and horizon.
Stromatocerium granulosum, montiferum, indianense Foerste, Bull. Denison Univ., 18, 1916, pp. 299-305, pl. 1, fig. 1; pl. 2, fig. 1.

This species forms large hemispherical or subglobular masses, frequently 30 cm. or more in diameter, surface usually marked by somewhat prominent mamillate elevations. Under an ordinary magnifier, the structure is seen to consist of a succession of papillose layers resting upon variable thicknesses of intermediate vesiculose tissue, both structures penetrated by vertical pillars. In cross-sections the pillars appear as short lines, indicating that they are laminar and very narrow, but not filiform; pillars not continuous throughout entire height of coralline growth, but appearing and disappearing at irregular intervals. In many cases, on weathered vertical sections, the vertical pillars resemble the walls of corallites, and the vesiculose tissue resembles transverse tabulæ crossing the interiors of corallites. This probably is why both Billings and Foord failed to distinguish between *Stromatocerium* and *Tetradium* in the specimens of *Stenopora huronensis* (page 72); the structure, however, is shown by cross-sections. The pillars grow in fascicles, pillars of the same fascicle spreading upward and outward from the centre of the fascicle toward the surface of one of the mamillate elevations. Usually the mamillate elevations of successive layers are almost directly over each other. When this is not the case, fascicles of successive layers may incline in different directions; papillæ on the surface of the laminar expansions much more numerous than the vertical pillars; on the mamillate elevations tending to have a radiate arrangement.

The type of *Stenopora huronensis* Billings consists of a *Tetradium* covered by a *Stromatocerium*. Billings studied chiefly the surface characters of this type, evidently belonging to the *Stromatocerium*, and his species usually is recognized under the term *S. huronense*. His type was found at Clay cliffs, in the Richmond.

Alveolites granulosus James was described from the *Orthoceras fosteri* zone at the base of the Clarksville division of the Waynesville, at Clarksville, Ohio. *Labechia ohioensis* was figured by Nicholson from near Waynesville, Ohio, probably from the same part of the Waynesville member as *Alveolites granulosus*. These three forms, *Stromatocerium huronense*, *Alveolites granulosus*, and *Labechia ohioensis*, all belong to practically the same horizon and species.

Stromatopora indianensis James was described from the *Beatricea nodulosa* horizon in the Elkhorn member of the Richmond, at Longwood, 5½ miles west of Connersville, Indiana. *Labechia montifera* Ulrich was described from the Hitz layer, at the top of the Saluda member, at Madison, Indiana. The fauna of the Hitz layer and that of the Elkhorn member have a sufficient number of species in common to be regarded as approximately equivalent. *Stromatopora indianensis* and *Labechia montifera* may belong to the same species, but differing from typical *Stromatocerium huronense*, the latter being a Waynesville species. The author, however, is unable to distinguish those representatives of *Stromatopora indianensis* which he has seen from typical *Stromatocerium huronense*, and *Labechia montifera* appears to him to consist merely of specimens of *Stromatocerium huronense* growing on Orthoceroids and other fossils. Further study may reveal differences.

Stromatocerium huronense is widely distributed in Ohio, Indiana, and Kentucky, as well as in Ontario and Quebec.

S. huronense australe Parks, figured from the Leipers division of the Maysville near Nashville, Tennessee, is abundant at the same horizon on Cumberland river in south-central Kentucky. At Wyoming, in the southern edge of Fleming county, Kentucky, it occurs at the *Platystrophia ponderosa* horizon in strata regarded as belonging to the Mount Auburn member of the Maysville; in Clark, Madison, and Garrard counties, Kentucky, in the upper half of the Arnheim, above the *Dinorthis carleyi* horizon; in Ohio in the *Orthoceras fosteri* horizon, at the base of the Clarksville; abundant in western Kentucky at the base of the Liberty, and at the top of the Saluda, extending along the upper horizon northward into Indiana. Isolated specimens from intermediate horizons differ enormously in size and appearance. Further study of these forms might establish species at present only vaguely apprehended.

Epithecal Layer. In exceptionally well-preserved specimens the basal part of *Stromatocerium* is covered by an extremely thin epithecal layer. Usually several centres of growth are observed, suggesting that a single coralline growth may originate from a number of growths originally distinct. Each separate point of origin forms the centre of a series of concentric wrinkles of the epithecal layer. Even when the layer has weathered away, this centre may still be recognized as the point from which radiate the vertical pillars which pass through the successive laminæ building up the coralline mass.

The species of *Stromatocerium* belonging to the *S. huronense* group are members of the southern fauna that entered by way of the gulf of Mexico. *S. rugosum* Hall, from the Black River of New York and southern Ontario, is a north Atlantic form that invaded southwestward as far as Tennessee and Alabama. The North Atlantic form is never associated with *Tetradium,* differing in this respect conspicuously from the southern forms of *Stromatocerium.*

Locality and Horizon. Found on Manitoulin island in the Meaford and in the overlying parts of the Richmond. At some elevations, notably about half-way between the Coral zone and the top of the Richmond, it tends to form reefs. It occurs also on the Cape Rich road north of Meaford, in the Coral zone at Streetsville, and at the same horizon on Snake island. It is common south of Reynold Point on Drummond island, and occurs also on Bay de Noc peninsula, in northern Michigan, in both cases in the Whitewater member of the Richmond.

Beatricea undulata Billings
Plate II, Figure 1

Beatricea undulata Billings, Geol. Surv., Can., Rept. of Prog., 1853-56 published in 1857, p. 344.

Beatricea undulata Foerste, Bull. Sci. Lab. Denison Univ., 14, 1909, p. 298, pl. 8, fig. 3.

Beatricea undulata Parks, Univ. Toronto Studies, geol. ser., No. 7, 1910, p. 43, pl. 25, figs. 1, 6, 7.

Erect, columnar growths with longitudinal, rounded ridges separated by broad, shallow grooves. Southeast of Lebanon, Kentucky, a sufficient number of these growths were found in an erect position in the rock to indicate that this was their normal position. The lower or radiciform end tapers rapidly downward. The remainder tapers slowly in an upward direction. Specimens usually do not exceed 60 mm. in diameter and 50 to 100 cm. in length, but on Anticosti much larger specimens are found. The ridges vary greatly in prominence, being only faintly indicated in some individuals. The columnar growth is built up by a succession of numerous concentric lamellæ which, on microscopic examination, resolve themselves into a cystose structure; numerous small cysts, concentrically arranged, surround a series of much larger cysts occupying the axial part, convex curvature of the small cysts directed laterally, and that of the large cysts in the axial portion directed upward. In specimens 30 mm. in diameter this axial part may be 7 mm. in diameter; in specimens 40 mm. in diameter, it may equal 10 mm. Along this axial part the cystose lamellæ not only are much larger but also are much more widely spaced; exterior surface of cystose lamellæ occupied by numerous minute granules.

In Ohio, Indiana, and Kentucky, *B. undulata* is not known below the Liberty. It occurs at the base of the Liberty in Bullitt, Nelson, and Marion counties, Kentucky, as far south as Liberty in Casey county, also at the corresponding horizon in Madison county. In upper Liberty found north of Canaan, Indiana, and near the base of the Saluda at Madison, Indiana. Much smaller specimens of the same general type were found 14 and 29 feet below the base of the Brassfield limestone, in the Elkhorn member of the Richmond.

Some of the *Beatricea* at Clay cliffs, near Wekwemikong, and north of Manitowaning, show scarcely any trace of vertical ridging or fluting, and correspond to *B. undulata-cylindrica* Foerste.[1]

Beatricea nodulosa Billings, from Anticosti island, occurs also at Stony Mountain, Manitoba; and in the Ohio-Indiana-Kentucky area. It differs chiefly in the presence of nodules in place of vertical flutings. In *Beatricea nodulifera* Foerste, from the Liberty member of the Richmond in Kentucky, the nodules are more numerous. Similar forms were found in Bay de Noc peninsula, east of Escanaba, Michigan, in the Whitewater.

Locality and Horizon. Beatricea undulata was described from Anticosti island, where it has a vertical range of 700 feet, including the upper three-fourths of the Vaurial and all except the upper 20 feet of the Ellis Bay members of the Richmond.

On Snake island it occurs in the Coral zone; on Manitoulin island, near Wekwemikong and Manitowaning, where it ranges from 43 to 60 feet above the *Hebertella insculpta* horizon; and also on Rabbit and Club islands, respectively 6 and 11 miles southeast of Wekwemikongsing. It is common in the Whitewater member of the Richmond south of Reynold Point, Drummond island, and occurs at the same horizon on Bay de Noc peninsula in northern Michigan.

Cornulites sp.
Plate XLVI, Figure 8

Cf. *Cornulites* sp., Hall, Pal. New York, 7, Supplement to 5, pt. 2, 1888, pl. 115.

Small, narrow, and nearly straight specimens of *Cornulites*, apparently not attached laterally to any body, range in the Nicolet River section, from the *Leptæna* to the *Proetus* and *Pholadomorpha* zones. Similar specimens occur in the Meaford 6 miles north of Meaford; at Clay cliffs; and at McLean hill.

Short but broad forms, adhering laterally to *Pterinea demissa* and *Whitella moniquensis*, occur in the Waynesville in the Nicolet River section.

[1] Bull. Denison Univ., 14, 1909, p. 298, pl. 9, fig. 7.

They average 12 mm. in length, 3·5 in width at their apertures. They are crossed by numerous transverse and rather prominent lines of growth, 3 to 5 in a length of 1 millimetre. Numerous sharply-defined vertical striæ occur with 8 or 9 in a width of 1 millimetre. Interior of specimens abruptly constricted at various intervals by transverse lines extending rarely more than a quarter of a millimetre inward from the inner wall of the tubes.

Spirorbis cincinnatiensis Miller and Dyer

Spirorbis cincinnatiensis Miller and Dyer, Jour. Cincinnati Soc. Nat. Hist., 1, 1878, p. 38, pl. 1, fig. 13.
Cf. *Cornulites* sp. Hall, Pal. New York, 7, Supplement to 5, pt. 2, 1888, pl. 115, fig. 2.

Coiled calcareous tubes, attached on one side to some shell or other support. Coil, as a rule, dextral, varying from a neat whorl, rapidly and regularly enlarging, 1·5 mm. in diameter, to larger growths with the larger end free, somewhat irregular in direction, spreading out over a total distance of 3 mm. According to Bassler, probably based on the young coiled specimens of *Cornulites*.

Locality and Horizon. A quarter of a mile south of Kagawong falls; very common at the *Rhytimya kagawongensis* horizon; and at Clay cliffs.

Burrow

Plate VI, Figure 4 *a*, *b*

The specimen is regarded as the cast of the interior of a burrow, made by some worm-like animal. On one side are four vertical rows of short, oblique elevations or ridges, such as could have been made by relatively distant folds of the skin formed during burrowing operations. In the left row, oblique elevations directed upward and toward the left, in the other three rows, directed upward and toward the right. The agreement in direction is best along the upper six sets of elevations. In the seventh set from the top, the elevation at the extreme right is higher than it should be, lower two or three sets quite irregular in their arrangement. The vertical row farthest to the right is most strongly elevated. The row next to the latter on its left is next in prominence. The elevation of the other two vertical rows is only moderate.

Locality and Horizon. Clay cliffs in the Meaford (No. 8581).

Arthraria biclavata westonensis var. nov.

Plate V, Figure 3

Arthraria biclavata Miller, Cincinnati Quarterly Jour. Sci., 2, 1875, p. 354, fig. 26.

The specimen consists of a groove terminating at each end in a transversely elliptical or elliptical ovate area. Groove 77 mm. long and 5 to 6 mm. wide; straightness and uniformity in width of its upper margin is its striking feature, but along one side of its basal part it is continued laterally for a width of nearly 2 mm. as a narrow, lateral crevice which slopes slightly downward and is, apparently, wrinkled slightly transversely; whether this is a constant feature and is duplicated on the other side of the groove is not known. The groove descends 3 mm. below the surface of the surrounding rock, at a point where the latter is 13 mm. thick, and presents no trace of the specimen on the lower side. The transversely elliptical disturbed area at one end of the groove 31 mm. wide and 22 mm. long in a direction parallel to the groove; at the other end 31 mm. wide and about 20 mm. long; both widest slightly nearer the exterior end of the disturbed areas, the exterior outline presenting a much smaller curvature than the remainder of the outline. This disturbed region is not known to be over 5 mm. deep and certainly does not reach the lower side of the thin slab. The frequency with which the tubes terminate in the elliptical disturbed areas gives rise to the popular name of *dumb-bell fossils*. Tubes of similar width and depth in the same layers do not always terminate in the disturbed areas, and yet are not known to represent distinct species of animals. Apparently the dumb-bell form was assumed only in some of the tubes. It is not known whether the entire specimen is the work of a single organism, or whether two organisms occupying the disturbed areas were connected along the intermediate tubular portion.

Arthraria biclavata was described by Miller from near Cincinnati, Ohio, where it is common in the Maysville. Similar specimens are common in the lower or Fort Ancient division of the Waynesville in Stony Run, southeast of Fort Ancient, Ohio. Thence it ranges into the upper parts of the Waynesville and into higher members of the Richmond.

As a rule it is assumed that all specimens of *Arthraria* of about the same size belong to the same species, but these specimens have not yet been carefully studied and compared.

Locality and Horizon. The specimen here figured and described is one of a series occurring along Humber river in the *Pholadomorpha* zone of the Lorraine; at the same horizon half a mile south of Clay cliffs; also at the base of the richly fossiliferous part of the Meaford member in the gully north of Manitowaning.

Arthraria rogersensis n. sp.
Plate IV, Figure 5

Arthraria cf. *biclavata* Miller, Jour. Cincinnati Soc. Nat. Hist., vol. 21, pl. 2, fig. 9, 1914.

One of the small forms of *Arthraria* occurs in the Cynthiana formation north of Rogers Gap, central Kentucky. The name *Arthraria rogersensis* is proposed for it. It differs from *A. biclavata* chiefly in its small size. Compared with the terminal globular enlargements, the intermediate connecting channel was short and broad.

Licrophycus hudsonicum Billings

Licrophycus hudsonicus Billings, Pal. Foss., 1, Geol. Surv., Can., 1865, p. 101, advanced sheets in 1862.

"This species forms large, fan-shaped tufts one foot wide, consisting of long, branched, cylindrical, usually much curved stems from 2 to 3 lines in thickness. It resembles *L. Ottawaensis*, but differs in the greater flexibility of the stems, the effect of which is to produce wide, straggling expansions instead of compact tufts.

"*Locality and Formation.* Manitowaning bay; in the upper part of the Hudson River group" (=Richmond). "Collector, R. Bell."

Licrophycus belongs to that group of markings, on the surface of rocks, formerly regarded as plants, but whose plant origin no longer is considered seriously. Some members of this group may represent worm borings; others may be of organic origin, but not related to plants. Unfortunately, the type of *L. hudsonicum* is lost, so that it is impossible to come to any definite conclusion as to this species.

Cyclocystoides huronensis Billings
Plate VI, Figure 3

Cyclocystoides huronensis Billings, Pal. Foss. 1, Geol. Surv., Can., 1865, p. 393, fig. 369.

Cyclocystoides huronensis Raymond, Bull. Victoria Mem. Mus., 1, 1913, p. 29, pl. 3, fig. 2.

Outline circular. Type consists of the central part of the dorsal disk surrounded by a submarginal ring of large plates, diameter of this ring 30 mm. That part of the ring which is preserved includes forty-five plates; from this it is concluded that the original number of plates was fifty-nine. Conspicuously elevated part of the plates 2·2 mm. long in a radial direction and 1·5 mm. wide laterally. Of this length of 2·2 mm., the inner part, 1·5 mm. in length, is occupied by a gently convex portion elevated above the rest; outer part, 0·7 mm. in length, lower and marked by one or two sharply-bordered oval impressions occupied by corresponding oval elevations. Exterior to this zone of oval-shaped elevations and depressions, plates of submarginal ring bordered by one or two spout-like appendages, about 1 mm. in length. Appendages ovate in outline, with their more acutely rounded tips pointing outward; corresponding in number to the number of oval depressions and elevations on the plates, the larger plates of the ring having two spout-like appendages, and the narrower ones having only one. Formerly, a series of very small marginal plates formed a zone extending about 2 mm. beyond the outer margin of the spout-like appendages, so that the entire organism was about 35 mm. in diameter, but of these marginal plates only traces remain at present.

The individual plates forming the central part of the dorsal disk, within the submarginal ring, cannot be distinguished. Branching radial lines pass from a confused central area outward, fifteen radial lines being counted in a part of the circumference including eighteen submarginal plates. Apparently these radial lines tend to terminate opposite twice their own number of spout-like appendages. No passage connecting the radial lines with these appendages is known. Radial lines low and broad, and bordered on each side of their median line by alternating series of depressions, about seven in a radial length of 4 mm. The more confused space at the centre is about 8 mm. in diameter.

The type of *Cyclocystoides huronensis* is not attached to a shell or similar organism, and, therefore, is regarded as having been free to move from place to place. Nothing is known of its ventral disk of plates.

So little is known of the general group of animals usually described under *Cyclocystoides* that the following notes may prove welcome.

In a specimen of *C. illinoisensis* Miller and Gurley, numbered 42,160 in the U.S. National Museum, the ventral or upper disk consists of numerous scutellate plates imbricating toward the centre of the disk. In other words, the inner margin of each plate overlaps slightly the outer margin of the plate next within, radially. Even the inner margin of the plates of the submarginal ring overlaps the adjacent plate of the ventral disk. This ventral disk is preserved well enough to demonstrate conclusively that no system of arms was incorporated in the disk as in *Agelacrinus*, and related genera. Although no oral aperture can be identified at the centre of this ventral disk, its presence is not excluded by any evidence here presented. At any rate, there appears to be no room for a central stem, as in the attachment disks of *Lichenocrinus*. The plates of the submarginal ring are flat on their upper surfaces, but present ovate vertical cross-sections with the pointed end directed inward and the rounded end downward and outward, the upper outer margin again being angular in vertical sections. Along their upper outer border these submarginal plates are minutely striated radially. The marginal zone of small plates imbricates towards the centre, as do all the other plates of the ventral disk. This specimen was obtained on Orchard creek, near Thebes, Illinois, at the type locality.

In a specimen of *Cyclocystoides*, with oval depressions and elevations on the outer part of the submarginal plates, preserved in the U.S. National Museum, and obtained in the Catheys member of the Trenton formation 2 miles west of Mount Pleasant, Tennessee, the dorsal disk within the submarginal circle of plates consists of numerous erect plates, like fence-palings in form, which incline inward sufficiently to be said to imbricate in that direction. The height of these more central plates is such as to have produced a strong support though still permitting a certain amount of flexibility. The marginal zone of very small plates is similar in character, but slopes outward. This outward sloping of the marginal plates is so frequent in *Cyclocystoides* as to suggest that these plates could be moved at will, either so as to slope inward, thus covering the outer margin of the submarginal ring of plates, or so as to slope outward, exposing the margin.

Locality and Horizon. Found on Rabbit island (No. 1998), lake Huron, associated with *Stromatocerium huronense* and *Beatricea undulata,* in strata regarded as above the Coral zone.

NEW CLASSIFICATION OF THE "HETEROCRINIDÆ"

By E. O. Ulrich

Intensive study of the Ordovician and Silurian crinoids in the U.S. National Museum, mainly comprised in the Springer and Ulrich collections, has indicated the desirability of a complete reclassification of the species hitherto commonly referred to the Heterocrinidæ. The number of genera is more than doubled by new groups here briefly defined for the first time. Of previously established genera, *Anomalocrinus* Meek and Worthen is made the type of a new family to which is added somewhat doubtfully the new genus *Geraocrinus; Heterocrinus* Salter, also seems more than generically distinct from *Heterocrinus;* and *Iocrinus* Meek and Worthen, either constitutes a family by itself or should be referred to some other family than the Heterocrinidæ. Finally, the remaining genera, together with the new genera, are divided between the Heterocrinidæ, as restricted, and the family Homocrinidæ recently proposed by Kirk.[1]

Briefly characterized the following classification of the American species is proposed:

Heterocrinidæ Zittel (emend. Ulrich)

HETEROCRINUS Hall

Heterocrinus tenuis Billings (part); Trenton formation of Ontario.
H. heterodactylus Hall; genotype; shaly lower part of Lorraine, New York; Eden shale, Cincinnati, Ohio.
H. exiguus Meek; Economy member of Eden, Cincinnati, Ohio.
H. exilis Hall; Economy member of Eden, Cincinnati, Ohio.
H. pentagonus Ulrich; Fairview limestone, Cincinnati, Ohio.
H. juvenis Hall; Corryville member of McMillan, Ohio.

ATYPHOCRINUS Ulrich

H. (*Atyphocrinus*) *corryvillensis* Ulrich; sub. gen. type; Corryville member of McMillan, Cincinnati, Ohio.
H. (*Atyphocrinus*) *juvenis* of collectors, not of Hall; Corryville member of McMillan, Lebanon, Ohio.

ISOTOMOCRINUS Ulrich

Isotomocrinus typicalus Ulrich; Lower Trenton, Kirkfield, Ontario.

DYSTACTOCRINUS Ulrich

Dystactocrinus constrictus Hall; Fairview limestone, Cincinnati, Ohio.

OHIOCRINUS Wachsmuth and Springer (emend. Ulrich)

Ohiocrinus laxus Hall; genotype; Fairview limestone, Cincinnati, Ohio.
O. oehanus Ulrich; Fairview limestone, Cincinnati, Ohio.
O. brauni Ulrich; Fairview limestone, Madison, Indiana.

COLUMBICRINUS Ulrich

Columbicrinus crassus Ulrich; lower part of Lebanon limestone, Stones River group, Columbia, Tennessee.

Anomalocrinidæ Ulrich

GERAOCRINUS Ulrich

Geraocrinus sculptus Ulrich; upper Chazyan, Ottosee shale, Knoxville, Tennessee.

Homocrinidæ Kirk (emend. Ulrich)

HOMOCRINUS Hall (emend. Kirk)

Homocrinus parvus Hall; Rochester shale, Lockport, New York.

ECTENOCRINUS Miller

Ectenocrinus canadensis Billings; Trenton, Ottawa and Montreal, Canada.
E. simplex (Hall); genotype; Eden and Fairview, Cincinnati, Ohio, and vicinity.

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[1] Kirk, Edwin, Proc. U.S. Nat. Mus., vol. 46, 1914, p. 479.

DRYMOCRINUS Ulrich

Drymocrinus geniculatus (Ulrich); genotype; Fulton member of Eden, Cincinnati, Ohio.

Drymocrinus manitoulinensis Foerste; Sheguiandah member of Eden, Manitoulin island.

DÆDALOCRINUS Ulrich

Dædalocrinus kirki Ulrich; genotype; lower Trenton, Kirkfield, Ontario.

D. bellevillensis Billings; lower Trenton, Kirkfield, Ontario.

SYGCAULOCRINUS Ulrich

Sygcaulocrinus typus Ulrich; Wykoff limestone, Richmond (Maquoketa) group, Fort Atkinson, Iowa.

Eustenocrinidæ Ulrich

EUSTENOCRINUS Ulrich

Eustenccrinus springeri Ulrich; genotype; lower Trenton, Kirkfield, Ontario.

E. milleri Wetherby; Lowville (Tyrone), High Bridge, Kentucky.

Family, **Heterocrinidæ** Zittel (emend. Ulrich)

Monocyclica (originally perhaps dicyclic), with small, irregularly constructed calyx and long, variously branching arms; basals five, equal; radials five, the right posterior and left anterior bisected transversely into super and inferradials; first anal plate rather large, usually resting on the left and right shoulders of, respectively, the right posterior superradial and the left posterior radial, always followed by a series of quadrangular plates that forms the support of a long, tubular or spirally coiled ventral sac; rays five, each with two to five primibrachs, the first of which commonly is partly or entirely included in the calyx; arms ten, non-pinnulate, dividing isotomously, heterotomously, or by throwing off long armlets which may divide repeatedly or remain simple.

HETEROCRINUS Hall

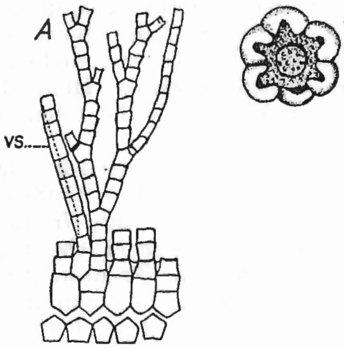

FIGURE 3. A. *Heterocrinus heterodactylus* Hall, diagram of cup, arms, and ventral sac. B. Tegmen of an undetermined species of *Heterocrinus*, probably *H. juvenis* Hall.

Anal x mainly supported by the shoulder of the right posterior superradial, but commonly touching also the left posterior radial; primibrachs sometimes three (*H.? corryvillensis* n. sp.), as a rule, four or five, the first larger than the others, tapering upward, and included partly or entirely in wall of calyx, the last an axillary bearing two equal rami, the second expanding in distal direction, the constricted articulation between the first and second primibrachs constituting a line of weakness in the crown that frequently resulted in the loss and subsequent regeneration of the rays. Rami ten, dividing, according to the species, on the third, fourth, or fifth secundibrach, the branches more or less unequal, the outer the smaller, and typically remaining simple to the distal extremity of the crown, the inner or main branch dividing in like manner again on the fourth to sixth tertibrach and once or twice again at similar intervals, the ramules alternating, the first being on the outer side, the second on the inner, the third on the outer side. In the possibly distinct round-stemmed group of species, including, besides *H.*? *corryvillensis* n.sp., another unnamed species that is commonly but erroneously referred to *H. juvenis* Hall, the ramules branch once or twice. Ventral sac tubular, relatively small and short, the anal x large and thick but the succeeding series of backing plates thin; remainder of wall of sac composed of small, apparently movable, plates. Tegmen gently convex, its middle on a plane with, or slightly beneath the top of, the fixed primibrachs. It is composed of a rather large polygonal central plate around which are many much smaller, loosely fitting plates. The smaller plates arch over the arm furrows, at least three rows being required to cover them. On the posterior side the small plates of the tegmen pass, evidently without break or change, into the anterior wall of the ventral sac.

Stem long, relatively large, quinquepartite, rounded except near the crown where in all but the oldest species (*H. tenuis* Billings) it is approximately pentagonal. Angles radial. Axial canal rather small, five-sided or star-shaped, its angles interradial. Stem ossicles of two or three sizes in the pentagonal proximal part, but only of two sizes in the rounded middle and distal parts. Those of the smaller set are always pentalobate, but, as growth proceeds, their lobes are likely to be concealed by excess development of the circular, larger disks. Root expanded, discoid or irregular in outline, the form depending on that of the object to which it is attached, with a crater-like depression in the elevated median part.[1]

Genotype. Heterocrinus heterodactylus Hall. Shaly lower part of the Lorraine formation, New York; and the Eden shale, Cincinnati, Ohio (Figure 3 A).

So far as known the genus is represented by eight or ten species and as many varieties, ranging from the Lower Trenton to the Lower Richmond. Of these, besides the genotype, only *H. exiguus* Meek, *H. exilis* Hall, both from the Economy member of the Eden shale, Cincinnati, Ohio, *H. tenuis* Billings (part.) from the Trenton of Ontario, *H. pentagonus* Ulrich, from the Fairview limestone, Cincinnati, and *H. juvenis* Hall (Figure 3 B) from the Corryville member of the McMillan formation, Ohio, have been described.

[1] The possibility that some of the plated disks described as species of Lichenocrinus are roots of Heterocrinus is conceded, but can not be discussed in this volume.

Sketches illustrating the structure of the calyx and arms of *H. Atyphocrinus corryvillensis* (Figure 4 A), one of the new species, from the Corryville member of the McMillan formation, Cincinnati, and of two related species, are given here. As stated in the generic description this new species, apparently also those round-stemmed species which have been erroneously referred by collectors to *H. juvenis*, differ from the more typical species of the genus in the subdivision of its arms, the armlets branching once or twice instead of remaining simple. However, the

ATYPHOCRINUS n. subg. (provisional)

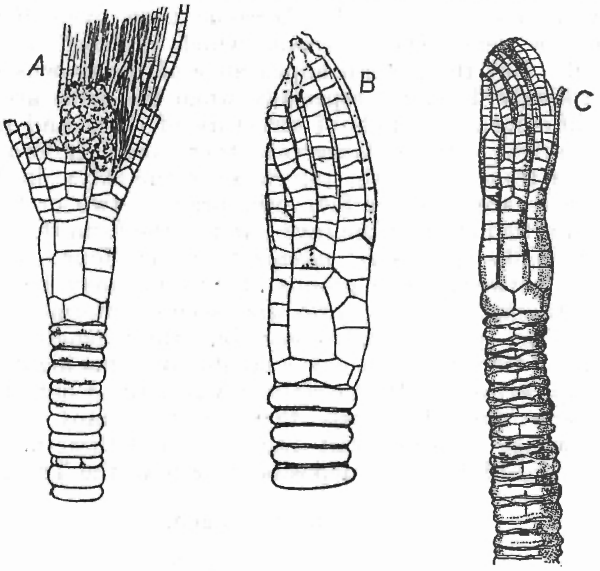

FIGURE 4. A. *Atyphocrinus corryvillensis* Ulrich n. subgen. et n.sp. Specimen, magnification: X 2, showing anterior side of cup, arms with bifurcating armlets, ventral sac, and part of column. B, sketch, magnification: X 2, drawn from a plaster cast of posterior side of crown of an undetermined but closely allied species; from the Maysville group at Cincinnati, Ohio. C, copy, magnification: X 2, of figure (Pal. Ohio, vol. 1, Pl. 1, fig. 3*a*) of anterior side of a specimen referred by Meek to *Heterocrinus juvenis* Hall. Although represented as having four primibrachs this specimen is regarded as a congener of *A. corryvillensis*. It is said to have been found at Lebanon, Ohio, and probably came from the McMillan formation in that vicinity. It is credited to the J. Kelly O'Neall collection and its present location is unknown.

branching of the armlets may not be essential. It has not been observed in the *H.*? *juvenis* (of collectors, not Hall) (Figure 4 C), none of the specimens at hand being entire. The stem in these species is also larger, attaining a diameter almost equalling that of the calyx, and is practically round throughout its length. Moreover, there is a tendency to reduce the number of primibrachs from four or five to three; the arms are relatively smaller and shorter, and the outlines of the crown and stem more parallel. Possibly these differences are more conspicuous than taxonomically important; but this is a point not easily determined. In the circumstances the provisional subgeneric designation, *Atyphocrinus*, is suggested for this peculiar group of crinoids, with the species *corryvillensis* as the type.

In its general aspect *Atyphocrinus* resembles *Eustenocrinus*. That genus, however, differs from this as well as from all the other heterocrinid genera in the structure of its calyx and arms, and, most importantly, in the fact that it has only four arms, the place of the fifth being occupied by the ventral tube. The difference in the calyx is notable, particularly in the fact that either all or none of its radials are compound. In fact, all the five rays, at least to the top of the fourth range of plates above the basals, are composed of similar successions of, first, pentagonal, and then, quadrate, radials and primibrachs, each of the transverse sutures running almost continuously around the body of the crinoid.

Probably a closer ally of *Atyphocrinus* than even *Heterocrinus* is found in the new genus *Dystactocrinus* which is based on *Heterocrinus constrictus* Hall. But the general appearance of the crowns in these two crinoids is strikingly different, especially when the arms are closed; and considerable difference in details of structure of calyx and rays is noted on closer comparison. In *Dystactocrinus* there are only two primibrachs and the lower of these makes the top range of the calyx; in *Atyphocrinus corryvillensis* there are three or four primibrachs—two or three of them above the basal articulation of the rays—and in the form that is commonly identified with Hall's species *H. juvenis* there are four. Just what the genetic relation between these groups of crinoids may be is uncertain. Structurally, *Atyphocrinus corryvillensis* seems intermediate between typical *Heterocrinus* and *Dystactocrinus*, but their genetic connexion is obscure. Judging from the data now available it seems highly improbable that either *Atyphocrinus* or *Dystactocrinus* was derived out of any known species of *Heterocrinus*. Evidently there existed many other kinds of heterocrinoids whose remains await discovery; and these must be looked for in Chazyan and Mohawkian deposits older than the Trenton.

ISOTOMOCRINUS n. gen.

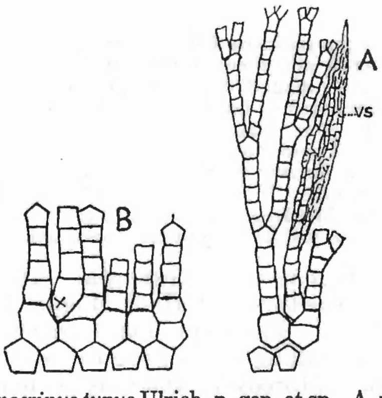

FIGURE 5. A and B. *Isotomocrinus typus* Ulrich, n. gen. et sp. A, posterior rays and ventral sac; B, diagram of cup, bases of arms and anal area.

Like *Heterocrinus*, except that the arms divide isotomously and are more strongly articulated with the radials; the proximal primibrach, except in the right posterior ray, is quite free and articulates with the radials; the anal x enters more deeply into the cup, and the ventral sac is more exposed, larger, and longer, reaching almost to the tips of the arms.

Genotype. Isotomocrinus typus n. sp. (Figure 5 *a*, *b*) Lower Trenton, Kirkfield, Ontario. Two other species, both undescribed and older, one from limestone of Black River age in central Pennsylvania, the other from the Upper Black River in Wisconsin.

In view of the obvious relationship of *Isotomocrinus* to typical *Heterocrinus*, also of the facts (1) that of the three species of *Isotomocrinus* two are older and one as old as the oldest of *Heterocrinus* and (2) that with the possible exception of the new *Columbicrinus* the arm structure of the other genera of the Heterocrinidæ, as here restricted, tends more and more to heterotomy, it seems likely that the isotomous method of arm subdivision characterized the primitive representatives of the family and that the heterotomous method was an acquired feature.

DYSTACTOCRINUS n. gen.

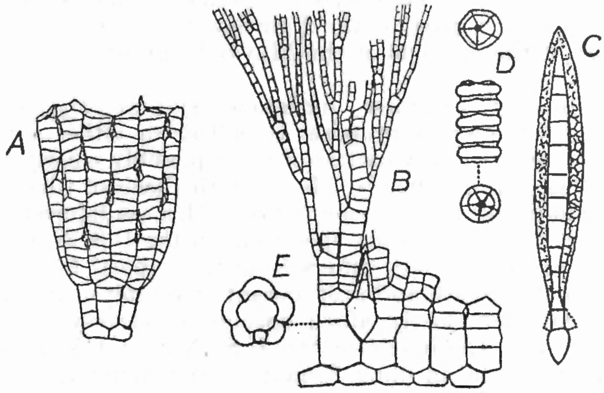

FIGURE 6. *Dystactocrinus constrictus* (Hall). A, copy of Meek's figure of the type of this species (Pal. Ohio, vol. 1, Pl. 1, fig. 10*a*) showing how the armlets are almost entirely concealed when the arms are closed. B, diagram of the calyx and part of the left posterior ray showing subdivision of arms. C, diagram of the ventral sac, from the posterior side. D, sketches of the column, the upper indicating its obtusely pentagonal cross-section just beneath the calyx, the middle and lower figures showing its character in side and end views. E, cross-section of the calyx showing its slightly pentalobate outline.

Basals short, the right posterior and left anterior radials transversely bisected as in *Heterocrinus;* proximal anal plate inserted deeply between the two posterior radials as in *Isotomocrinus*, extending downward to the base of the right posterior superradial and being laterally apposed to the first primibrachs of the right and left posterior rays; ventral sac fusiform, about half as long as the arms; primibrachs two, the lower fixed in the calyx, the upper an axillary, the articulating contact between the two somewhat constricted, the articulation correspondingly weak; each of the five rays dividing into two main, equal, strong rami, of which each third to fifth ossicle throws off a slender, long armlet that divides isotomously several times; armlets arising alternately on the two sides of the rami and only the backs of their undivided proximal extremities partly visible externally when the arms are closed. Stem superficially appearing round, but obscurely pentagonal in cross-section, particularly in the proximal portion.

Genotype. Heterocrinus constrictus Hall. Fairview limestone, Cincinnati, Ohio (Figure 6 *a-e*).

This genus is proposed for the reception of at least four species of crinoids. The oldest of these is represented by a single specimen in the Springer collection found in the Trenton limestone, Ottawa. The second also is known only from a single specimen found in the Upper Trenton Cynthiana limestone, in the bank of Ohio river, at West Covington, Kentucky. The third also is represented by a single good head that was found in the Fairview limestone at Covington, Kentucky, and is now in the Ulrich collection. It lacks the constriction at the top of the calyx and exposes more of the armlets than do the other species when the arms are closed. The fourth was named many years ago by Hall, who called it *Heterocrinus constrictus*. Somewhat imperfect remains of the last are common in the upper part of the Fairview limestone, Cincinnati, Ohio, but, like most of the crinoids of the Maysville group, good specimens are rare.

The commoner Fairview limestone species—*Dystactocrinus constrictus* (Hall), as the writer proposes to call it—is either a very variable species or there are several varieties of it, or possibly closely allied species. One of these was distinguished by Meek, on the basis of what appears to be a young individual, as variety *compactus*. This, as figured by Meek and as corroborated by several larger specimens in the U.S. National Museum indicates that Meek's variety differs from the typical form of the species in the much greater length and protuberant character of the fixed proximal primibrach. Another closely allied species or variety of *D. constrictus* is indicated by two specimens in the U.S. National Museum that were found by the writer in an older formation at Cincinnati, namely, in the McMicken member of the Eden.

The genetic origin of these species is doubtful. Apparently they represent a line of development that had been established at the beginning of the Trenton and ceased with the close of the Maysville. As its known history begins with the Trenton, *Dystactocrinus* could not have been derived from any known heterocrinid of the genera *Heterocrinus, Ectenocrinus,* or *Iocrinus*. All these, like *Dystactocrinus,* were in existence and had attained typical development long before the close of the Trenton age. Genetic connexion between these several genera seems most probable, but the actual points of contact must be in as yet undiscovered pre-Trenton ancestors. The oldest species of each are, apparently, as distinct from each other as are the youngest. In other words, there is no satisfactory evidence of progressive differentiation of the heterocrinid genera from the beginning of the Trenton to the close of the Cincinnatian.

As to which of the Heterocrinidæ, as here defined, is the nearest to *Dystactocrinus*, the evidence seems to favour *Heterocrinus* and possibly *Columbicrinus* rather than *Ohiocrinus* to which the type species was referred by Wachsmuth and Springer and all subsequent authors who simply accepted that determination without investigation. The fact that *D.*

constrictus has a rather short and simply tubular or fusiform ventral sac altogether different from the long, closely coiled, spiral sac of *Ohiocrinus* should be sufficient to debar it from that genus. A comparison of the primibrachs confirms this opinion, for they are distinctly and constantly fewer in the new genus than in *Ohiocrinus*. In *D. constrictus* and the other species here associated with it there are two primibrachs. In *Ohiocrinus*, on the contrary, there are at least three and commonly four or five.

The new genus *Columbicrinus* agrees with *Dystactocrinus* in having only two compound radials and also in having only two primibrachs in at least four of its rays. But the genotype of *Columbicrinus* has the crown broken off at the top of the first pair of secundibrachs, so that nothing is known of the higher parts of its arms. Still, if it really had infrabasals, as the specimen clearly suggests, it can hardly be counted as a close ally of *Dystactocrinus*.

Ectenocrinus also agrees with *Dystactocrinus* in the number of its primibrachs, there being constantly two. However, the primibrachs of *Ectenocrinus* differ from those of *Dystactocrinus* in that their sides are subparallel and not constricted at their junction, so that the demarcation between the first primibrach, and the second (axillary) primibrach is not so evident as in *Dystactocrinus*. Beyond the primibrachs the rays of *Dystactocrinus* differ decidedly from those of *Ectenocrinus*. In the latter the rami are rigid and their lateral divisions very slender, undivided, pinnule-like processes that are completely concealed when the arms are closed. In *Dystactocrinus*, on the other hand, the bases of the armlets are visible externally in closed crowns, and when fully exposed they bifurcate two or more times. *Ectenocrinus* differs further in having three compound radials instead of only two, and on that account the two genera are referred to different families.

Comparison with *Heterocrinus*, as restricted (under the mistaken name *Stenocrinus*) by Wachsmuth and Springer[1] and further restricted by the writer, shows that the main differences between its species and those of *Dystactocrinus* are in their respective arm structures. Thus, in typical *Heterocrinus* there are from three to five primibrachs in each ray instead of only two. Following the first bifurcation of the rays—which results, as usual in the family, in ten equal rami—they divide again, according to the species, on the third, fourth, or fifth secundibrach. This second division may be almost equally dichotomous, except that the outer branch remains simple to its tip at the extremity of the crown. The inner branch, however, always divides two or more times, the branches being slightly unequal in width, the lesser again remaining simple and being given off in alternating manner from the two sides of the main branch. The arm division in *Heterocrinus*, therefore, is heterotomous whereas in *Dystactocrinus* it is metatomous. But, aside from this difference, the closed crowns in the two genera are made to look very different by the fact that in *Heterocrinus* the armlets are visible externally to their tips, whereas in most *Dystactocrinus* only their undivided proximal ends are exposed to view.

[1] Rev. Paleocr., pt. 3, sec. 2, p. 205, in Proc. Acad. Nat. Sci. Philadelphia, 1886.

Structure of calyx, normally, as in *Heterocrinus* and *Dystactocrinus*, but subject to great variation in number, form, and arrangement of plates because of breakage and irregular regeneration of parts. Primibrachs four or five, the first larger than the others and fixed; arms long, the first division isotomous, the two rami dividing thereafter in alternating heterotomous manner on each succeeding fourth to s xth ossicle; armlets reaching to top of crown, exposed, commonly dividing once or twice cr remaining simple. Ventral sac spirally coiled, long, extendi g well up toward the tips of the arms. Stem subpentagonal in its upper part, rounded in its middle and lower parts, in these and all other essential features as in *Heterocrinus*.

OHIOCRINUS Wachsmuth and Springer (emend. Ulrich)

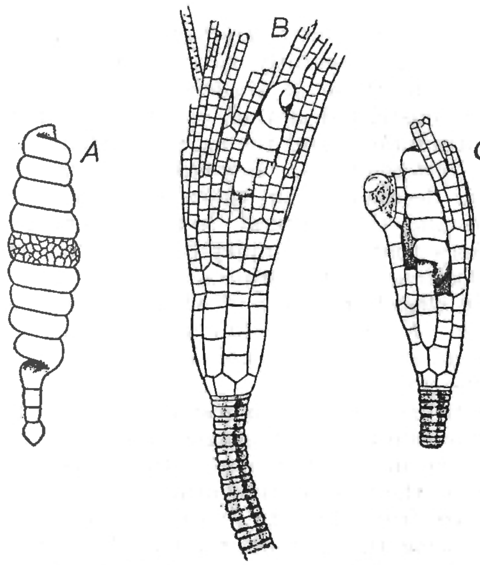

FIGURE 7. A, *Ohiocrinus laxus* (*Heterocrinus laxus* Hall) the anal series and spiral ventral sac. B, *Ohiocrinus brauni* Ulrich, n.sp., left anterior side. C, posterior side of the cotypes of this species. B and C, magnification: X 3, from the Fairview limestone at Madison, Indiana. Types in the Springer collection in the U.S. National Museum. This new species differs from *O. oehanus* in being smaller and in the simple, undivided character of its armlets.

Genotype. Heterocrinus laxus Hall (or *Heterocrinus oehanus* Ulrich) (Figure 7 *a*). Only three, or perhaps only two, species of this genus as here restricted are known. The doubt as to the number arises from the prevailing uncertainty as to the relations of *O. œhanus* (Ulrich) and *O. laxus* (Hall). They may not be distinct. However, before it be decided that these two names are synonymous, their respective types should be critically compared. The writer has not succeeded in locating the original of Hall's species. In the meantime it can do no harm to continue recognizing them as probably distinct. The third species, for which the name *Ohiocrinus brauni* (Figure 7 *b, c*) is proposed, differs from *O. œhanus* and presumably also from *O. laxus* in its smaller size, but mainly in the fact that its armlets remain simple instead of dividing two or more times. All these species have been found only in the Fairview limestone, Cincinnati, Ohio, and Madison, Indiana.

In the general form of the crown, also in the character of its arms, the arrangement of the plates of the calyx, and the form and character of the stem, *Ohiocrinus* agrees best with typical *Heterocrinus*. The only difference of generic import lies in the ventral sac. This forms a spirally coiled tube and, as a rule, constitutes a conspicuous feature in most specimens. The ventral sac of *Heterocrinus*, on the contrary, is a narrow, simply tubular structure that has been clearly observed in only a single example out of hundreds.

COLUMBICRINUS n. gen.

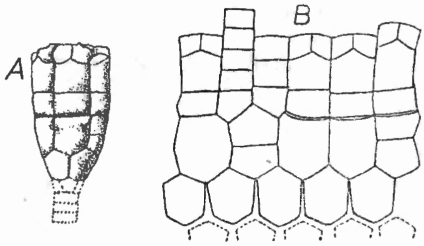

FIGURE 8. *Columbicrinus crassus* Ulrich n. gen. et sp. Lebanon limestone of the Stones River group, Columbia, Tennessee. A, anterior view of type specimen. B, diagram of plates of cup and rays so far as known; the infrabasals indicated by dotted lines in both drawings.

A heavily plated crinoid, apparently dicyclic, with five long, hexagonal basals, five radials, two of them, the right posterior and left anterior, transversely bisected as in *Heterocrinus* and all other genera of this family; primibrachs large, as wide as the radials, parallel-sided and in contact laterally, two in each of the rays except the right posterior, which has three, the proximal one articulating with the radial, the second or third an axillary bearing two equal secundibrachs; proximal plate of the anal series resting on the sloping shoulders of the right posterior superradial and the left posterior radial, succeeded by an arm-like series of shorter plates.

Genotype and Only Known Species. Columbicrinus crassus n. sp. (Figure 8 *a, b*). Lower part of the Lebanon limestone, Stones River group, Columbia, Tenn. Unfortunately the only known specimen of this species is broken at the bottom of the basals and the top of the first secundibrachs. What there is of it conforms, so far as the basals and radials are concerned, very well with Heterocrinidæ. However, it differs from most of them—the exception is *Isotomocrinus*—in the articulation of the rays with the fixed plates of the calyx being at the base of the proximal primibrach instead of at its top. It differs further in the lateral contact of the arms, a feature in which it agrees much better, as it does also in the number of the primibrachs, with *Ectenocrinus*. In so old a representative of this general type of crinoids it seems altogether proper to find it combining characteristics of both Heterocrinidæ and Homocrinidæ. But the specimen suggests another feature that was not expected. Namely, on examining the bottom of the specimen five facets were observed. If these facets be considered in connexion with the large size and rounded outline of the open space enclosed by the walls of the calyx, they must be viewed as indicating a cycle of infrabasals. This conclusion is reached despite the well-known fact that very similar facets are commonly observable in the base of the cup of Heterocrinidæ. But in none of those cases is the central open space nearly so large or so rounded as in the specimen under discussion. On the contrary, the opening always is small and angular, agreeing in size and form with the axial canal of the stem.

Family Doubtful, Perhaps Anomalocrinidæ

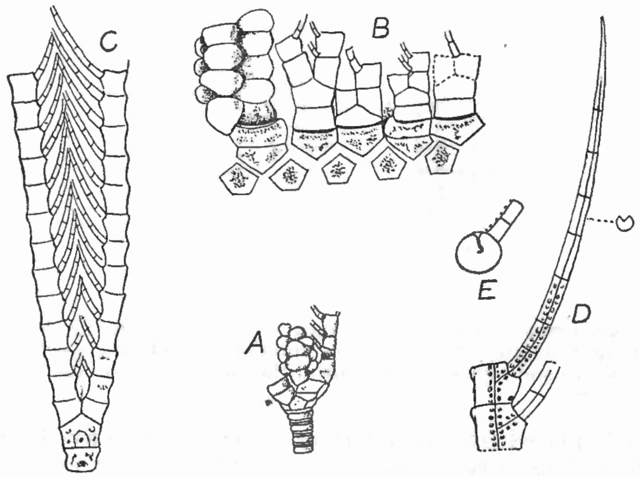

FIGURE 9. *Geraocrinus sculptus* Ulrich n. gen. et sp. Ottosee shale, Blount group, Knoxville, Tennessee. A, basal part of the crown, from the posterior side, showing form of calyx, a small part of the column, and the lower part of the ventral sac. B, enlarged diagram of the calyx and lower parts of the arms and ventral sac. C, diagrammatic view of the lower half of a ray showing the endotomic arrangement of the pinnules. D, two of the arm ossicles and pinnules from the inner side, showing narrow food grooves. E, end view of ossicle.

GERAOCRINUS n. gen.

Calyx small, broadly obconical, monocyclic, composed of thick, strongly nodose or rugose plates. Basals five, rather large, and regularly pentagonal; radials small, the left anterior and right posterior compound; anal plate rather large, not included in calyx though resting on the sloping shoulders of the two posterior radials. Rays dividing but once, giving ten simple, strong, and long arms as in *Ectenocrinus;* primibrachs few, one in the anterior ray, two in each of the others, nearly as wide as the radials; secundibrachs quadrangular, thick, rounded in cross-section, each with a long pinnule given off from its upper inner angle so that the pinnuliferous sides of each pair of arms are opposed; arm furrows deep but very narrow. Ventral sac of moderate size, shaped like an ear of corn, composed of four ranges of thick, protuberant, interlocking plates. Column of moderate size, round, quinquepartite, made up of three sizes of columnals, the latter arranged alternately; axial canal of medium size, rounded-pentagonal, the angles interradial.

Genotype. *Geraocrinus sculptus* n. gen. et sp. (Figure 9 *a-e*). Upper Chazyan, Ottosee shale, Knoxville, Tennessee. In the structure of the calyx *Geraocrinus* agrees with *Heterocrinus* and its allies and also with *Anomalocrinus*, which is otherwise quite different. Its undivided ten arms, on the other hand, are as in *Ectenocrinus*. That it is probably a nearer kin to *Anomalocrinus* than to any of the known genera of either the Heterocrinidæ or the Homocrinidæ is suggested by its thick, rounded arms and narrow food grooves, and also by the fact that each of the arm ossicles bears a pinnule. The evidence for the suggested relation to *Anomalocrinidæ* is further strengthened by the restriction of the pinnules to one side of the arms. Still, although the evidence clearly favours alliance with *Anomalocrinus*, the resemblance to the Heterocrinidæ is sufficiently striking to suggest the probability that the genotype of *Geraocrinus* represents the stock from which both *Anomalocrinus* and the Heterocrinidæ—particularly *Dædalocrinus*—were derived.

Family, **Homocrinidæ** Kirk (emend. Ulrich)

Monocyclica, with small, irregularly constructed calyx and moderately long, simple or variously branched, arms; basals five, subequal; radials five, three compound, the right posterior and right and left anterior bisected transversely into super- and inferradials; proximal anal plate

HOMOCRINUS Hall (emend. Kirk)

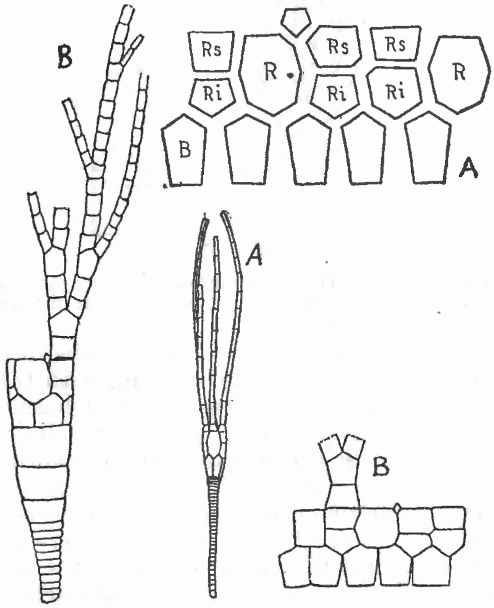

FIGURE 10. A and B. *Homocrinus parvus* Hall, Rochester shale, New York, a nearly complete crown, magnification: X 4, and diagram of calyx (after Kirk).

resting on the truncated shoulders of the posterior radials, followed by a series of quadrangular plates that forms the support of a tubular or balloon-shaped ventral sac; rays five, rarely remaining undivided, but usually branching, the first time isotomously, the subsequent divisions variously unequal.

A minute, primitive type, probably by reversion after *Ectenocrinus*. Cup fusiform, slender, with five narrow and unusually long basals, the radials, both the simple and compound, and the anal x, as required by the family; arms long, slender, undivided, the first brachial short, its lower articulating side as wide as the radial beneath it, tapering upward to the much smaller width of the succeeding longer brachials; neither armlets nor pinnules observed. Column round, tapering like the calyx for some distance downward from the base of the cup. Columnals uniformly thin in the tapering part, beyond which they gradually separate into two sizes—nodals and internodals.

Genotype. Homocrinus parvus Hall, as redefined by Kirk[1] (Figure 10 *a* and *a*), Rochester shale, Lockport, N.Y.

ECTENOCRINUS Miller

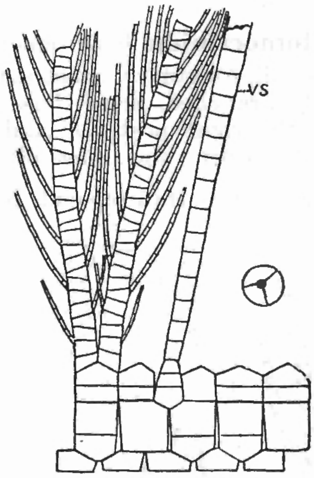

FIGURE 11. *Ectenocrinus simplex* (Hall). Diagram showing arrangement of plates of calyx, the left anterior ray, ventral sac, and cross-section of tripartite column.

Calyx essentially as in *Homocrinus*, even to the downward extension of its taper for some distance on to the column, with this difference, that the basal plates are shorter and the two pairs of basal plates that meet beneath the undivided anterior and left posterior radials not only make a straight sutural contact with the rectangular radials mentioned, but the concerned basals also tend to become fused. Anal x resting, as usual, on the sloping shoulders of the two posterior radials, succeeded by two smaller plates, which are visible externally, and then by a very gradually widening concealed series of larger but thinner quadrate plates that form the backing of a long, narrow, tubular ventral sac. Primibrachs nearly or quite as wide as the radials, two in each ray, both rather short, the second an axillary, the five pairs of succeeding rami long, unbifurcated, rigid, closely fitting laterally and tapering slowly toward their distal extremities; every second ossicle gives off a slender, long pinnule in alternating manner on

[1] Op. cit., p. 4.

the two sides of each arm, the first in each pair of arms being on the outer sides of the ray, the second on the inner sides, the third again on the outer sides. Column long, round, of medium diameter, tripartite, composed of uniformly thin disks for some distance beneath the calyx, but of alternating thin and much thicker joints in its middle and lower parts.

Genotype. *Heterocrinus simplex* Hall. Hall's original figures of *Heterocrinus simplex* (Figure 11) show pretty clearly that they were made from a crushed specimen of the species with short arm pieces, and not, as thought by Meek and authors generally, of the common Eden form that differs only in being smaller and in having proportionally (perhaps actually) longer ossicles. It appears, therefore, that Meek's variety *grandis* is really the true *Ectenocrinus simplex*.

Billings' *Heterocrinus canadensis* is another form of this genus that the writer is unable to distinguish satisfactorily from *Ectenocrinus simplex*. No well-marked and constant differences were found in comparing the general aspect and also details of structure of crowns of equal size from Trenton, Eden, and Fairview specimens. In all cases, whether they come from the Trenton at Ottawa, or Trenton Falls, New York, or from the Eden, or the Fairview near Cincinnati, Ohio, the growth of the arm pieces from youth to old age is almost entirely in lateral direction. Consequently, in young specimens the length of the arm pieces may equal or even exceed their width, whereas in older specimens the length remains nearly the same and the width increases until it becomes fully twice the length.

Though the small specimens—that is, those in which the length of the crown does not exceed 1 inch—at first sight seem quite distinct from those in which the crown has grown to a length of 2 inches, the numerous specimens of intermediate sizes grade so perfectly from the one extreme to the other that it appears impossible to draw a sharp line between them. And yet it seems altogether improbable that this crinoid could have persisted without sustaining some recognizable structural modification from the upper beds of the Trenton through the Eden and thence to the middle of the Maysville stage. True, as crinoids go, its structure is very simple and, therefore, liable to range through long ages without suffering readily notable changes in its structure. Besides, only a few specimens are so well preserved as to permit detailed comparison of its many parts. There is a suggestion now and then of small differences in the proportions of the plates of the calyx. The pinnules also seem not entirely alike in all; and the structure of the stem is not always the same. Then, it is to be said that the average size of the specimens in each of the zones differs more or less. The difference in this respect is particularly notable when the collections of *Ectenocrinus* from the lower members of the Eden shale are compared with those found in the shaly layers of the Fairview limestone.

But the means of testing these possible criteria are not readily available. At any rate the practical benefit of their possibly successful application has not seemed great enough to warrant the laborious effort to work them out.

In contrast with this long-ranging uniformity of the structural type, to which the term *Ectenocrinus simplex* now seems properly applicable, are the early Trenton and the Richmond representatives of the genus. The former occurs in the Curdsville limestone—the first Trenton deposits in central Kentucky. Precisely similar specimens have been found, also, in the presumably corresponding lower Trenton crinoid beds near Kirkfield, Ontario. Unfortunately, none of the specimens of this species preserves more than the cup, the bases of the arms, and a part of the column. However, what is known of it conforms accurately with the generic characters of *Ectenocrinus*. Compared with *E. simplex* the cup is more slender, and tapers more gently and more regularly into the expanding proximal part of the column. Further, the basal plates are relatively shorter, but the first primibrachs, which, moreover, appear to be fixed in this early Trenton species, are decidedly longer and appear to taper slightly upward. The last feature suggests that the crown may have been slightly constricted at the base of the arms.

The Richmond species has been found only in northern Iowa and southern Minnesota, where it occurs with other crinoids in the Wykoff limestone in the lower part of the group. The plates of the calyx and the arm ossicles are uncommonly thick and the backs of the arms seem less rounded than usual. A more important, or at least more serviceable difference, when compared with preceding forms of *E. simplex*, is that the cup is relatively shorter and the radials wider. Another feature that is much better developed than in *E. simplex* is the practical fusing of two pairs of the basals.

DRYMOCRINUS n. gen.

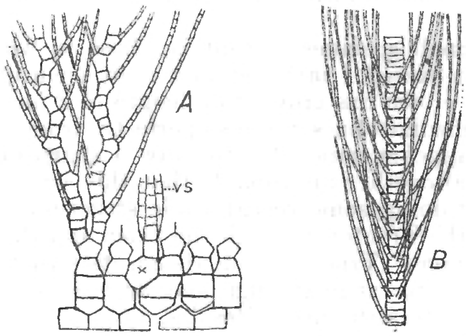

FIGURE 12. *Drymocrinus geniculatus* (Ulrich). Fulton shale of the Eden group, Cincinnati, Ohio. A, diagram of calyx, left anterior ray and ventral sac. B, part of the column with cirræ.

Structure of calyx and number of primibrachs the same as in *Ectenocrinus*, except that the basals beneath the undivided radials are never fused and the contact between the two primibrachs is constricted. The ventral sac also is somewhat wider and has a series of thin quadrate plates on either side of the median series. The main and more conspicuous differences lie in the arms. These are not rigid but geniculated, each third or fourth, and, later, each second, ossicle being prominent and thicker than the others and supporting a long, slender pinnule or undivided armlet. Column round, cirrose, quinquepartite, composed of rather thin disks, particularly in the proximal part; axial canal pentalobate; cirræ numerous, very slender, weakly attached, directed obliquely upward and so long that they must have concealed the greater part of the crown.

Genotype. *Heterocrinus geniculatus*, Ulrich. Fulton member of the Eden shale, Cincinnati, Ohio (Figure 12). At present only two species of this genus are known. A description and figures of the second, evidently a somewhat younger representative, are published in this volume under the name *Drymocrinus manitouliensis* (Plate VII, figures 1*a-f*). Judging from photographs transmitted by Foerste the new Manitoulin species differs from *D. geniculatus* in having relatively thicker arms, shorter basals, and pinnuliferous brachials that are more often separated by only one without pinnule, whereas most of the middle and lower thirds of the arms in the Cincinnati species are separated by two.

That *Drymocrinus* is closely allied to *Ectenocrinus* is shown clearly enough by their respective diagrams in Figures 11 and 12. However, when their arms and ventral sacs are compared and the noted differences are added to the fact that cirræ are wanting in the one and abundantly developed in the other, the propriety of their generic separation can hardly be doubted. The cirrose character of the column in *Drymocrinus* constitutes by itself an excellent distinguishing mark, and doubtless would be most useful in recognizing the genus if they were not so easily broken away. However, knowing that they do occur under exceptional conditions of preservation, their stumps will be looked for and may be recognized on the less favourably preserved specimens. When this criterion fails, the greater rigidity of the arms and more numerous though much less striking display of pinnules in *Ectenocrinus* may be relied on. In fact, in that genus the pinnules are completely concealed when the arms are closed, whereas in *Drymocrinus* the zigzagging of the arms renders their entire concealment impossible. The column of *Drymocrinus* differs from that of *Ectenocrinus* not only in having cirræ, but also in being quinquepartite instead of tripartite. As a rule, too, the average thickness of the columnals is less in *Drymocrinus* than in *Ectenocrinus*.

Structure of calyx essentially as in *Ectenocrinus* and *Drymocrinus* except that the basals are all similarly pentagonal, the radials are shorter, the cup correspondingly lower and its downward taper is not carried over onto the proximal part of the column. Besides, the column is decidedly larger and distinctly pentagonal instead of round in its upper half. The ventral sac is much larger and balloon-shaped. There are four primibrachs in the right posterior ray and either three or four in the other rays. The rami subdivide in endotomic manner, each third or fourth ossicle giving off its inner side a long undivided armlet or stout pinnule that extends to the summit of the crown.

Genotype. *Daedalocrinus kirki* n. gen. et sp. (Figure 13 *a-c*). Lower Trenton crinoid bed, Kirkfield, Ontario. The genotype is represented in the Springer collection in the U.S. National Museum by a number of excellently preserved specimens collected by Dr. Edwin Kirk, after whom the species is named.

Besides the genotype this genus will include, so far as known, only Billings' *Heterocrinus bellevillensis*. Both species are found in the same bed near Kirkfield. They are readily distinguished by conspicuous though perhaps not very important differences, so that they may be accepted as unquestionable congeners. *D. bellevillensis* is characterized by great length of crown and strikingly rigid rami and armlets. The armlets are relatively thick and lie close beside each other. In *D. kirki*, on the contrary, the crown is distinctly shorter, the rami not quite so heavy, and the armlets curve outwards so as to leave unequal spaces between them and at the same time to give them a somewhat straggly appearance.

Having three or four primibrachs *Daedalocrinus* suggests relations to *Heterocrinus* and *Ohiocrinus*. Indeed, this type may appear as intermediate in structure between Heterocrinidæ and Homocrinidæ. But such a conception would have no other basis than that furnished by the number of the primibrachs, and this, of course, is not a determining factor. Otherwise good Heterocrinidæ, like *Dystactocrinus*, have only two primibrachs the same, as in the Homocrinidæ genera *Ectenocrinus*, *Drymocrinus*, and

DAEDALOCRINUS n. gen.

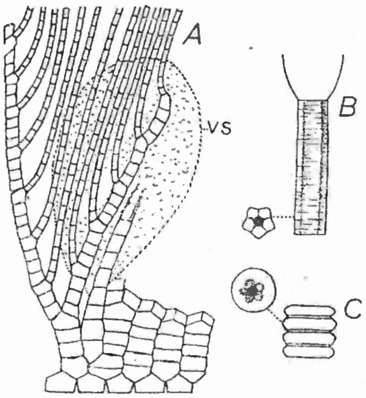

FIGURE 13. *Daedalocrinus kirki* Ulrich n. gen. et sp. Trenton limestone, Kirkfield, Ontario. Types in the Springer collection in the U.S. National Museum. A, diagram showing arrangement of plates in calyx, the ventral sac, and subdivision of left posterior ray. B, upper part of rather smooth pentagonal column, with cross-section below and outline of cup above. C, showing larger size of column and its rounded and annulated character 4 or 5 inches beneath the crown.

Sygcaulocrinus. In *Homocrinus* itself the rays are undivided and the number of primibrachs, therefore, unlimited. Moreover, the endotomic method of arm division that obtains in *Daedalocrinus* is readily explained by the dropping out of the axillaries which bore the outwardly directed armlets or pinnules, and under this interpretation more easily correlated with the paratomic method, which prevails in *Ectenocrinus* and *Drymocrinus*, than with the heterotomic and metatomic methods that are commonly followed by the most typical of the Heterocrinidæ.

Generically *Daedalocrinus* is readily distinguished from its nearest allies *Ectenocrinus* and *Drymocrinus* by the endotomic instead of paratomic division of its arms, and the larger size and balloon-like inflation of the ventral sac. The less conspicuous differences in the plates of the calyx and in the column are mentioned in the generic description. Compared with genera assigned to the Heterocrinidæ it is distinguished at once by the fact that three of its radials instead of only two are transversely bisected.

SYGCAULOCRINUS n. gen.

In having a round, tripartite, thin-plated, downwardly tapering column, three compound radials, and two primibrachs the peculiar crinoid on which this genus is founded shows its near relationship to, and also strongly suggests its derivation from, *Ectenocrinus*. The arms, however, above the primibrachs, are much smaller and divided at longer intervals—so sparsely, in fact, that the result suggests the heterotomic method prevailing in *Heterocrinus* rather than the paratomic which occurs in *Ectenocrinus* and *Drymocrinus*. Still, the branching of the arms in *Sygcaulocrinus* is essentially paratomic, differing from its more usual expression only in that the lateral divisions (ramuli) are exceedingly few—only two or possibly three on each side of a ramus. The proximal anal plate seems very small and lies in a minute notch between the top angles of the two posterior radials.

The most striking peculiarity of the genotype is the extraordinary development of the three upper disks of the column. These, in thickening and widening gradually from the normal thin columnals beneath them, form a cone that passes without constriction into the cup and exceeds the latter in height. The result is a calyx that, in general aspect, reminds one greatly of such Mesozoic crinoids as *Apiocrinus* and *Bourgeticrinus*.

Genotype and only Known Species. *Sygcaulocrinus typus* n. gen. et sp. (Figure 10 B and B). Wykoff limestone, Richmond (Maquoketa) group, Fort Atkinson, Iowa. In its relatively simple arm structure *Sygcaulocrinus typus* is regarded as approaching the reversionarily primitive *Homocrinus parvus* Hall, a middle Niagaran (Rochester shale) fossil in western New York. It also has an elongate obconical cup that is not easily distinguishable from the similarly tapering column. But, instead of the upper columnals being thickened, the uncommon length of the cup is produced in *Homocrinus* by elongation of the radials and basals, particularly of the basals.

Family, **Eustenocrinidæ** n. fam.

EUSTENOCRINUS n. gen.

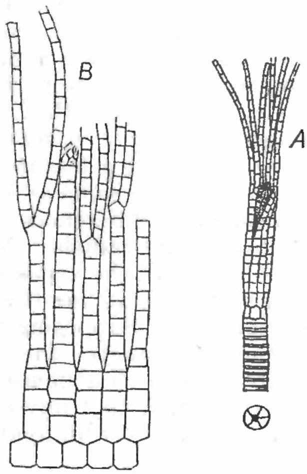

Figure 14. *Eustenocrinus springeri* Ulrich n. gen. et. sp. Trenton limestone, Kirkfield, Ontario. Holotype in Dr. Frank Springer's collection, after whom this extraordinary crinoid is named. A, anterior side of specimen, slightly enlarged, with cross-section of column. B, diagram of plates, the four arms and the ventral tube resting on the right posterior radial.

Crown long, slender, calyx narrow, column round, smooth, quinquepartite, its diameter approximately equalling that of the crown, composed of two alternating sets of thin columnals, one thinner than the other. Basals five, pentagonal, apparently at least imperfectly fused so that the sutures are not as plainly visible as between other plates. Above the basals and in radial position are five similar rows of plates arranged in four somewhat irregular transverse cycles; the first cycle—radials—is higher than the others and composed of five nearly equal pentagonal plates; those making the second, third, and fourth cycles are quadrangular and interpreted as primibrachs and anals incorporated in the cup. Four of these rays are succeeded by somewhat narrower, rounded free arms. The fifth, supposed to be the right posterior ray—it might be called an anal series—does not support an arm, but continues with a similar series of less convex quadrate plates that constitutes the support of a long, tubular ventral sac. Accordingly there are only four arms. These may bifurcate once, twice, or possibly three times, the first division occurring on the sixth to the tenth piece above the cup, the second on the next sixth to tenth, or wanting.

Genotype. Eustenocrinus springeri n. gen. et sp. (Figure 14 *a* and *b*). Lower Trenton crinoid bed, Kirkfield, Ontario. Type in the collection of Dr. Frank Springer, after whom the species is named. The type specimen was embedded in the surface of a slab of limestone, but has been carefully freed from the matrix by the writer, so that it now shows all sides of the crown very satisfactorily.

A second species of *Eustenocrinus* was long ago described by Wetherby[1] under the name *Heterocrinus milleri*. Wetherby founded his species on two good specimens which he collected from the Lowville (Tyrone) limestone at High Bridge. In the work cited he gives not only a good description of all the characters shown by these specimens but also a good figure of the more complete example. This retains the crown almost complete and about an inch of the column. Both the specimens are embedded in limestone and, judging from the description, neither exposes the right posterior ray. At least no mention is made of a ray that bears no free arm, but passes upward into anals supporting a ventral sac. Possibly the Kentucky species does not agree with *E. springeri* in this respect. However, the two species agree so closely in general aspect that it seems unlikely they can differ in so important a feature. Indeed, the Kirkfield specimen was at first believed to be the same as Wetherby's species, until closer scrutiny revealed considerable differences in the branching of the arms and in the size of the basals and radials. Namely, in *E. milleri*, as described and figured by Wetherby, all the exposed rays bifurcate at least twice, and two of the second pairs of branches divide again, giving a total of six branches from the single ray. Supposing that the five rays were divided in like manner, Wetherby estimated the total number of arms as thirty or more—which probably is an overestimate by six. In *E. springeri*, on the contrary, there is no indication that any of the four arms divided more than once; and in each instance this bifurcation occurs higher up on

[1] Wetherby, A. G., Jour. Cin. Soc. Nat. Hist., vol. 3, p. 153, pl. 5, fig. 3, 1880.

the arms than the first of the divisions in *E. milleri*. In the right anterior ray of the new species the first and only bifurcation occurs on the tenth plate above the basals, in the anterior ray the thirteenth plate is an axillary, in the left anterior ray eleven plates occur without a division, and in the left posterior the eleventh plate is the only axillary. The right posterior supports or passes into the ventral sac. The basal and radial plates in the new species are both relatively much longer than in the Kentucky species. Finally, the two species occur in different geological formations, the stratigraphic position of *Eustenocrinus springeri* being in the Lower Trenton, whereas *E. milleri* was found in beds corresopnding to the upper part of the Lowville limestone.

Drymocrinus manitouliensis sp. nov. (Foerste)
Plate VII, Figure 1 *a-f*.

Cf. *Drymocrinus geniculatus* (Ulrich), Jour. Cincinnati Soc. Nat. Hist., 2, 1879, p. 16, pl. 7, figs. 13 *a-c*. (Published under *Heterocrinus*.)

Differing from the type of *Drymocrinus geniculatus* chiefly in its more robust size. Compared with the size of the radials and primibrachs, the arms are less attenuate.

Basals 5, pentagonal. Radials 5, theoretically, but the right posterior, and the right and left anterior radials are divided by transverse sutures into two each, known as inferradials and superradials. The proximal anal plate rests on the truncated shoulders of the posterior radials, but for a greater width on the right posterior radial than on the left one. The proximal anal plate is followed by a series of quadrangular plates, but the character of the ventral sac is not shown by the specimens at hand. Judging from specimen 8578 *d*, this ventral sac was large and somewhat twisted. Primibrachs always 2, as a rule shorter and inclined to be slightly narrower than the radials. The lower primibrach narrows toward the top, and the upper widens, the two together suggesting faintly the so-called hour-glass structure. General form of calyx obconic. Each axillary primibrach supports two arms; arms heterotomous, ramules rising alternately on opposite sides of the arms; arm joints uniserial. Theoretically, the ramules should rise from successive arm-joints, but on opposite sides of the arms. In fact, however, the arm-joints are divided by transverse sutures into two, or even three segments, of which only the upper one supports the ramule. Using the term hypozygal for the lower segment of the hypothetical arm-joint, and epizygal for the upper one, the term mesozygal becomes appropriate for the middle segment. Three segments are common for the first two or three hypothetical arm-joints of the various arms; two segments occur in the following ones. Occasionally the first arm-joint consists of only two segments, but in that case the following one or two consist of three segments. The three segments occur rarely in the fourth arm-joint. Sutures between the segments of the same arm-joint usually nearly directly transverse; those between the successive hypothetical arm-joints strongly oblique, sloping first toward one side and then toward the other side of the arm, so as to face upward always on the side of the epizygal segment which supports the ramule. On the larger or ramule-supporting side of each hypothetical arm-joint, the lateral outline usually is straight, but the opposite or shorter side is distinctly concave. This produces the peculiar zig-zag or geniculate structure characteristic also of *Drymocrinus geniculatus* Ulrich, from the Fulton shale at the base of the Eden, Cincinnati; but in general the arm-joints of the Manitoulin specimens are much less slender than those of the Cincinnati species. In none of the Manitoulin specimens are the ramules well shown, but their length is known to exceed 7 mm.

Locality and Horizon. Northeast of Tamarack point (No. 8578). In the Sheguiandah formation. St. Hyacinthe (No. 8587); a single specimen resembling *Drymocrinus manitoulinensis* in the geniculate character of its arms was found (Plate VII, figure 2).

Iocrinus subcrassus (Meek and Worthen)

Heterocrinus subcrassus (Meek and Worthen), Geol. Surv. Illinois, 3, 1868, p. 325, pl. 4, figs. 5 *a-d*.

Fragments of the strongly pentagonal stem are common, but only the basal fragment of one calyx was found. This presents the five basals, strongly depressed along the middle; two of the radials, strongly angulate along the middle toward the basal margin; and one of the primibrachs. The strong angulation of the basal part of the calyx is well shown.

This species was described originally from some part of the Cincinnatian series of rocks at Cincinnati. The exact horizon is not known. According to Nickles it not only ranges from the Eden through the Maysville and into the Richmond, but it occurs also in the Cynthiana formation beneath the Eden.

Locality and Horizon. At the top of the hill on the Sheguiandah road, 3 miles south of Little Current (No. 8577). From the limestones in the upper part of the Sheguiandah.

Lichenocriuns obliquus sp. nov.
Plate VI, Figure 2

Disks attached to columns of crinoids, the columns being about 3 mm. in diameter. Along the length of these columns, the disks occupy a space of 4 mm. or less, and encircle the columns more than half way. At the time the disks became attached the crinoids were alive, as is shown by the oblique growth of the disks, which enabled them to support the columns of a much smaller crinoid in an erect position. The disks are merely highly specialized expanded bases of columns of minute crinoids belonging to the *Heterocrinidæ*, as shown long ago by the discoveries of August Albers, a diligent collector of Cincinnati, Ohio, who brought together a wonderful series of these remarkable organisms, some of which retained the calyces. Calyces are present also in the Springer collection in the U.S. National Museum. The area of attachment of the normal stem of the Heterocrinid to the disk-like expansion at its base is abruptly depressed, and slopes in a direction distinctly oblique to the column of the crinoid which supports the disk. The base of the stem of the Heterocrinid is made up of five columns composed of numerous small segments, alternating to some extent at their lateral lines of contact.

Among the *Heterocrinidæ* there appears to be a group of species which, by means of a somewhat flattened convex, round disk at the base of their columns, attach themselves to some solid support, usually the surface of some brachiopod or other relatively smooth body. The upper or exposed surface of this attachment disk is made up of distinct plates, the relative number, size, arrangement, and convexity of which vary in a manner suggesting the presence of distinct species even when only the disk is known. The central part of the disk is depressed, and the central part of the disk either supports the basal part of a column or presents a distinct area of articulation for the support of this column. The column, at its base, usually is made up of numerous small segments which tend to be arranged in five vertical columns, but, farther up, the columnals consist of complete disks as in other crinoids. The crowns attached to the top of these columns are so minute that they are rarely seen by collectors. There is a tendency on the part of the columns to become smaller in an upward direction, the crown being only slightly wider than the smallest part of the column. The individual plates of the crown are visible, but it is difficult to secure a definite conception as to their outlines. As far as known, these crowns suggest forms related to the *Heterocrinidæ.*

Lichenocrinus is especially common in Ohio, Indiana, and Kentucky, ranging from the Cynthiana formation to the top of the Richmond. In Minnesota, and at Stonington, east of Escanaba, Michigan, it is known from the Richmond. A specimen was found at Silliman mount at the head of Frobisher bay, among material identified as Trenton.

Locality and Horizon. Half a mile south of Clay cliffs (No. 8579), in the Sheguiandah.

Compsocrinus harrisi (Miller)
Plate VI, Figure 1 *a, b, c*

Glyptocrinus harrisi Miller, Jour. Cincinnati Soc. Nat. Hist., 4, 1881, p. 74, pl. 1, figs. 4, 4*a*.

Specimen poor, but shows characteristic features of this species.

Column quadrangular at its attachment to the calyx. Only a few columnals remain. Flat surface of the joints smooth, excepting along the margin which is bordered by a narrow row of short striæ perpendicular to the outline of the columnals. In cleaning the specimen, the column became detached, revealing four basals. Right posterior ray consists of a radial and two primibrachs, followed by two secundibrachs, and the first two tertibrachs, the remainder being broken off. In the left branch of the right anterior ray are three secundibrachs. All these radials and brachial plates present long, narrow, and strongly convex dorsal axes of about the same prominence, and all these axes tend to be strongly incised at the distal ends of the axillary plates. Anal series of plates rests on one of the larger basals; it consists of a vertical series of rather large plates deeply sculptured with stellate ornamentation, characteristic of *Compsocrinus harrisi,* figured on the plate accompanying the original description of the species. Traces of similar ornamentation noticed, also, along the margins of the radial and brachial plates. This type of sculpturing continued down to the basals. The specimen had at least ten arms.

On the same rock fragment a second specimen preserves only traces of several of the brachial series, but their dorsal axes are so strongly and narrowly convex as to warrant referring this second specimen also to *Compsocrinus harrisi*. A number of the arms are well preserved. The free parts are fully 35 mm. long, originally equalling perhaps 40 mm. Ossicles uniserial, and somewhat cuneate. Pinnules numerous, those near the upper ends of the arms being at least 10 mm. long. Those on each side of the arm arise from alternate ossicles.

Locality and Horizon. Clay cliffs, in the Meaford (No. 8576). The type of this species was found in the Waynesville, near Waynesville, Ohio.

Tæniaster meafordensis Foerste

Plate VIII, Figures 1, 2, 3, 4

Tæniaster meafordensis Foerste, Bull. Denison Univ., 17, 1914, p. 326, pl. 4, figs. 5-7.

Central disk 7 to 8 mm. in diameter, rays 11 to 15 mm. in length. Therefore, total spread of the animal, including rays, about 35 mm. Rays 2 mm. in width at attachment to the disk, tapering gradually toward their extremities.

Ambulacral groove occupied by two rows of ambulacral plates, about eight in a length of 5 mm. Those on opposite sides of the median line alternate. In form, boot-shaped. Just above the foot of the boot, constricted, so that a convex outline is produced along the median line of the ray by top of one boot together with foot of next following boot in a distal direction. This convex outline fits into the concave outline at mid-length of the boot on the opposite side of the median line of the ray, in alternate order. At the ankle of some of the boots is a tiny depression or pit, but it does not occur on all ambulacral plates, nor is there evidence of its terminating at the base in a pore passing through the plate. Tip of foot of boot blunt and slightly enlarged, apparently for articulation with adumbulacral or side plates.

Adumbulacral plates about four-thirds as long as umbulacrals, so that they overlap in a distal direction. Viewed from the side of the ray, they appear to be oval. Apparently each plate bears a single spine attached near the middle of its upper margin. In length this spine nearly equals the adumbulacral plate. Outer surface of plates poorly exposed. There may have been more than one spine on each plate, but it is regarded as unlikely.

Exterior surface of the adumbulacral plates convex. Attachment of inner surface to blunt tip of boot-shaped ambulacrals by means of a short pedicle, as in *Alepidaster granuliferus* Meek[1] was not evident in any specimen, although an indistinct suggestion of such a structure is presented by some of the plates that belong to those parts of the rays within the central disk. Apparently the adumbulacral plates articulate at their base with tip of foot of boot-shaped ambulacrals, and, along one side, also with lateral margin of the double row of plates forming dorsal side of ray. No structure of this kind has been described from related genera, and better preserved specimens must be sought to verify the description.

[1] Schuchert, Charles, "Revision of Palæozoic Stelleroidea," Bull. U.S. Nat. Mus., 88, 1915, p. 229, fig. 26.

Syngnaths much shorter and relatively thicker than in *Tæniaster spinosus*[1] presenting the appearance of short, blunt V's, rounded and raised at the apex.

Dorsal side of rays presents two median rows of plates, quadrangular in outline and alternating on opposite sides of the median line. Together with the adumbulacral plates, which overlap them laterally, they present a strongly convex transverse section.

It has not been possible to verify the presence of any deep depression or connexion with the interior of the ray in any of the spaces between the ambulacral and adumbulacral plates, along the umbulacral groove. In some cases, at least, such a podial passage seems impossible owing to the presence of solid material in plain view along every possible part where such a passage might be looked for.

Entire dorsal surface of rays, and of the central disk, and the part of actinal side of disk that is between the rays, appears to have been covered with a thin, minutely granular integument. Some granules are larger and may have supported minute spines or other appendages.

Locality and Horizon. Workman creek, 3 miles southeast of Meaford, in the Meaford (No. 8580).

Only one species of *Tæniaster* has been described previously from the Richmond, namely *T. elegans* Miller, from the Waynesville near Waynesville, Ohio.

T. elegans is figured as being approximately of the same size. Syngnaths are longer and more acute; adumbulacrals not figured as distinctly overlapping; spines represented as considerably longer than adumbulacrals. In the text it is stated that one spine arises from each plate. Although more than thirty specimens were found on a single slab, the central disk was not differentiated, by the author of this species, from the rays. The figure shows boot-shaped ambulacrals very distinctly and, like the Workman Creek specimens, fails to show distinct pedicle for the articulation of the adumbulacral plates with the tip of boot, differing in this respect from *Alepidaster*. *T. meafordensis* evidently is closely related to *T. elegans*, but, if the above differences hold good when direct comparison is made with the type of *T. elegans*, then *T. meafordensis* is a distinct species.

Owing to the poor state of preservation of *T. meafordensis* it is necessary to compare this species with *Alepidaster*, since two Richmondian species of this genus are known which present a somewhat similar aspect to *T. meafordensis*. Ambulacral plates boot-shaped, but there is a distinct pit on ambulacral side of boot, at its ankle. Plates patelliform and supported by distinct pedicles. Schuchert, moreover, states that the abactinal side of the rays had no dorsal plates, but was covered by an integument or was finely granular. No structure corresponding to that of *Alepidaster*, as here described, was found in *T. meafordensis*.

Alepidaster granuliferus Meek[2] is about the same size as Workman Brook specimens. Central disk and minute pit at angle of boot-shaped ambulacral plates distinctly figured by Meek, but no boot-shaped outline shown such as that presented by Schuchert. Pedicle for attachment of

[1] *See* Schuchert, Charles, loc. cit., p. 218, fig. 17.
[2] Ohio Pal. I, p. 68, pl. 3, bis, fig. 8, and Schuchert, Charles, loc. cit. p. 229, fig. 26.

adumbulacral plates is a striking feature, and the close-set granules, figured by Meek, form another characteristic structure. Type specimen obtained at Moore hill, Indiana, in the Waynesville.

Alepidaster miamiensis Miller[1] is somewhat larger than the Workman Brook specimen. Central disk distinctly seen. The figure fails to show the boot-shaped outline of ambulacrals, although the reference of this species to *Alepidaster* by Schuchert suggests this form of ambulacrals must have been present. Adumbulacral plates figured as bearing two spines of remarkably short lengths. Syngnaths terminate bluntly and have moderately diverging sides. If this species belongs to *Alepidaster* it evidently requires refiguring. Type found near Waynesville, Ohio, probably in the Waynesville.

Rhombotrypa quadrata (Rominger)
Plate IX, Figure 2

Chætetes quadratus Rominger, Proc. Acad. Nat. Sci. Philadelphia, 1866, p. 116.

Rhombotrypa quadrata Cumings, 32nd Ann. Rept. Dept. Geol. Nat. Res. Indiana, 1908, p. 877, pl. 23, figs. 4, *4b;* pl. 25, fig. 5.

Specimens with branches attaining a diameter of 12 mm. Eleven cells occupy a length of 3 mm. Gener'c character may be recognized in the field most readily by breaking a branch across, and moistening the end of the branch. In this case the central parts of branch will appear divided into minute squares by equidistant lines that cross each other nearly perpendicularly. On closer inspection a similar tendency towards arrangement in rectangularly crossing series is noticed among the apertures on the surface, cells being to some extent in groups, members of the same group showing the rectangular outlines and arrangement.

Locality and Horizon. Clay cliffs (No. 8551); northwest of Manitowaning; north of Meaford; Streetsville; and on Snake island. From the Richmond, chiefly from the Waynesville member. The species occurs practically wherever the Richmond is known and at almost every horizon.

Constellaria polystomella Nicholson
Plate IX, Figure 1

Constellaria polystomella Nicholson, Pal. Ohio, 2, 1875, p. 215, pl. 22, figs. 7, *7a.*

Constellaria polystomella Cumings, 32nd Ann. Rept. Dept. Geol. Nat. Res. Indiana, 1908, p. 808, pl. 13, figs. 1 *a*, *b*, pl. 28, fig. 1.

Specimens forming somewhat flattened branching fronds, many 20 mm. or more wide, and 3 or 4 mm. thick. Stellate maculæ mostly on boldly elevated prominences, many half a millimetre high, and 2 to 3 mm. across.

Locality and Horizon. A characteristic fossil of the Richmond, from the Waynesville upward, in Ohio, Indiana, Kentucky, Illinois, and Wisconsin. Clay cliffs (No. 8550) and Streetsville.

[1] Jour. Cincinnati Soc. Nat. Hist., 5, p. 116, pl. 5, fig. 6.

Leptobolus insignis Hall
Plate X, Figure 1

Leptobolus insignis Hall and Clarke, Pal. New York, 8, pt. 1, 1892, p. 74, pl. 3, figs. 1-6.

Shells very small, as a rule not over 2 mm. long; ovate in outline; moderately convex. Shell semiphosphatic, and somewhat glistening, with faint traces of radiating striæ; concentric striæ distinct.

Locality and Horizon. Lower part of the Sheguiandah, south of Little Current.

Originally described from the Utica of Middleville, New York, recorded also from Ottawa, Ontario. It is listed by Dr. Rudolf Ruedemann from the Canajoharie shale. At Cincinnati, it is listed from the Fulton member of the Eden. This member is regarded as being the nearest approach to the Utica found in the Cincinnati area.

Lingula hyacinthensis sp. nov.
Plate XI, Figure 4 *a, b*

Species belonging to *Lingula cobourgensis* Billings group, but shell somewhat less elongate, and, therefore, more rotund. Shell substance black and shiny; concentric striæ very fine, but no radiating striæ noticeable. Valves only moderately convex, even for a *Lingula*. Length of both specimens figured, 11 mm.

Locality and Horizon. *Cryptolithus* zone, Lorraine. Below dam, in river bed, St. Hyacinthe (No. 8589).

Compared with *L. curta* Conrad, from the Trenton slate at Carlisle, Pennsylvania (Plate X, figure 3), the posterior end is much less attenuate. *L. curta* is listed by Ruedemann as ranging from the lower part of the Canajoharie shale upward into the Dolgeville, the passage beds from the Canajoharie into the Utica.

L. cobourgensis was described by Billings from the Trenton at Cobourg; listed also from Ottawa and Collingwood; doubtfully identified from Minneapolis, Minnesota.

L. rectilateralis Emmons, associated with *Triarthrus*, figured by Emmons among Utica fossils. Stated by Ruedemann[1] to occur in good specimens in Schenectady beds, and as coming from middle and upper Trenton. Hall identified with this species two specimens from the Lorraine of New York, near Lorraine.[2] One of these figures is reproduced here as Plate X, figure 2. A specimen from the Lorraine east of Pulaski, New York, is figured on Plate XXXI, figure 14.

Trematis millepunctata Hall
Plate X, Figure 5 *a, b, c*

Trematis millepunctata Hall and Whitfield, Pal. Ohio, 2, 1875, p. 70, pl. 1, figs. 4-7.

Shells approximately circular, with beak of brachial valve projecting moderately beyond circular outline. Pedicle valve with large, open fissure

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[1] "The Lower Siluric Shales of the Mohawk Valley," New York State Mus. Bull., 162, 1912, p. 91, pl. 4, fig. 1.
[2] Pal. New York, 1, 1847, p. 285, pl. 79, figs. 1 a-c.

for emergence of pedicle. Valve strongly elevated toward this fissure, but even more strongly depressed along its margin. Brachial valve rather evenly convex. Surface covered with minute circular pits more or less arranged in radiating furrows.

An unknown species of *Trematis*, much larger than *T. millepunctata*, occurs in the Lorraine-like strata south of Little Current. Larger than any other species hitherto found in the Richmond, but is not very well preserved for description.

Locality and Horizon. In the Waynesville, Snake island. Originally described from Cincinnati, Ohio, where it ranges from the Eden to the Richmond.

Crania scabiosa Hall

Plate X, Figure 8

Crania scabiosa Hall and Clarke, Pal. New York, 8, pt. 1, 1892, p. 148, pl. 4 *h*, figs. 23-28, 30, 31.

Forms small, irregularly circular elevations on the surface of *Strophomenidæ* and other places of support. Surface convex, usually reproducing the character of ornamentation found on its support, though there is a tendency toward even convexity with concentric striation.

Locality and Horizon. Clay cliffs, south of Little Current, and Vars; and Snake island. In the Waynesville.

Described originally from Cincinnati; range Eden to Richmond. Known also in Indiana, Kentucky, Tennessee, and Wisconsin. Similar specimens occur in the Richmond at Stonington, Michigan.

Schizocrania filosa (Hall) Plate X, figure 4, is so common in Maysville and Richmond strata in Ohio, Indiana, and Kentucky, and in the underlying Trenton, that its occurrence in corresponding Canadian strata may be expected.

Pholidops subtruncata (Hall)

Plate X, Figure 7; Plate XI, Figure 1

Pholidops subtruncata Hall and Clarke, Pal. New York, 8, pt. 2, 1892, pl. 41, fig. 19.

Shells small, outline oval, anterior end narrower, posterior end showing tendency toward truncation. Shell concentrically striated, convex, with its apex about one-fourth length of shell from the truncated posterior margin. Length 4 or 5 mm.

Locality and Horizon. In the Nicolet River section, *Pholidops subtruncata* occurs in the *Leptæna*, *Proetus*, and *Pholadomorpha* zones of the Lorraine. It occurs in the *Proetus* zone, also, at the mouth of Huron river, at Chambly Canton, St. Hilaire, Hawthorne, and Ramsayville. In the Waynesville, Vars.

Pholidops subtruncata was described originally from the Lorraine of New York.

In Ohio and Indiana, it is replaced by a very similar form, *P. cincinnatiensis* Hall (Plate X, figure 6) in both Eden and Maysville strata.

Dalmanella sp. (Lorraine species)

Plate X, Figure 9 *a, b, c*

In the Lorraine of Quebec and Ontario *Dalmanella* is widely distributed, but no detailed study has been made of the various forms in these horizons.

In the Nicolet River section *Dalmanella* ranges from the *Cryptolithus* zone, through the *Leptœna, Proetus,* and *Pholadomorpha* zones. Common in lower and middle Lorraine, but far less common in *Pholadomorpha* zone, and not recorded from the Waynesville. In the *Cryptolithus* zone near St. Hugues, and along the road southwest of Petite Caroline. In the *Proetus* zone at Chambly Canton, and near Vars, Hawthorne, and Ramsayville. In *Pholadomorpha* zone south of St. Hilaire.

Species in the equivalents of Eden and Maysville strata in Ontario and Quebec do not resemble typical *Dalmanella multisecta* (Meek) as much as the larger form figured by Meek[1] from 250 feet above Ohio river at Cincinnati, presumably from the Mount Hope member of the Maysville. See Plate X, figure 9, *a, b, c,* reproductions of some of the figures presented by Meek.

Dalmanella testudinaria (Dalman). It has long been customary to identify the American Ordovician species of *Dalmanella,* irrespective of size, form, or surface ornamentation, as *D. testudinaria,* but the publication, by Raymond, of excellent figures of a typical specimen of that species from the type locality at Borenschuldt, Sweden,[2] shows the impropriety of this procedure. No specimens strictly agreeing with *D. testudinaria* are known on the American continent, a fact long known by students of our brachiopoda. The great variety and abundance of our American Ordovician *Dalmanellœ,* call for a monographic treatment of the genus, rather than a description of isolated species. Certain types of structure, such as those shown by *D. rogata* (Sardeson) and *D. whittakeri* Raymond, recur at numerous horizons, with slight differences in size, shape, and surface ornamentation, easy to recognize but difficult to describe.

Dalmanella originated early in Palæozoic time, six species and two varieties being known already in the Canadian group of strata, below the Ordovician.

In the Richmond of Quebec *Dalmanella* is known only from wave-strewn blocks on Snake island, but there fairly common.

On Manitoulin island, *Dalmanella* is common in the Sheguiandah, and in the lower part of the Wekwemikongsing, below the Pholadomorpha horizon.

Dalmanella manitoulinensis sp. nov.

Plate XI, Figure 2

Largest specimen found, 8 mm. long, 9 mm. wide. Convexity of pedicle valve 1·5 mm., valve strongly elevated at beak, with maximum curvature along median line. Height of hinge-area 1·7 mm. Brachial valve distinctly convex, with broad median depression distinct as far as

[1] Geol. Surv., Ohio, Pal. 1, 1873, pl. 8, figs. 2 a, b, c.
[2] Geol. Surv., Can., Mus. Bull. No. 31, 1921, p. 14, pl. V, figs. 3, 4.

anterior margin. Striations as in specimens of *Dalmanella jugosa* of the same size. Specimens differing from that species chiefly in their smaller size.

Locality and Horizon. Meaford, Clay cliffs (No. 8526).

Hebertella occidentalis (Hall)

Plate V, Figure 5 *a*, *b*; Plate X, Figure 10 *a*, *b*

Orthis occidentalis Hall, Pal. New York, 1, 1847, p. 127, pl. 32*a*, fig. 2 *a-m;* pl. 32*b*, fig. 1 *a-i*.

Hebertella occidentalis Foerste, Bull. Sci. Lab. Denison Univ., 14, 1910, p. 53, pl. 2, figs. 1, 2.

Shells frequently 30 to 35 mm. wide. Brachial valve strongly convex, frequently with a median fold anteriorly. In typical forms a faint depression along the median line near the beak. Hinge-area of pedicle valve diverges strongly from the plane separating the valves. Radiating plications numerous, secondary plications being intercalated among primary ones in more or less alternate order. Muscle impression in interior of pedicle valve ovate-oblong in outline, deeply impressed, and tending to be heart-shaped along its lower margin.

Hebertella sinuata (Hall) differs chiefly in the greater coarseness of the radiating plications, especially the primary ones, before the intercalation of additional plications begins (Plate X, figure 11).

Locality and Horizon. In Ontario and Quebec relatively rare in the Lorraine, but listed in the *Proetus* zone, from Hawthorne and Ramsayville. In the *Pholadomorpha* zone, from the Nicolet River section; also south of Clay cliffs.

Abundant in the Meaford at Gore Bay, Kagawong, south of Little Current, at Manitowaning, Clay cliffs (No. 8510), Meaford, Oakville, Streetsville, Vars, on Huron river, in the Nicolet River section (No. 8439), and on Snake island.

In the Kagawong member of the Richmond formation, it occurs at Manitowaning and west of the Indian village southwest of Little Current.

Glyptorthis insculpta (Hall)

Plate X, Figure 14

Orthis insculpta Meek, Pal. Ohio, 1, 1873, p. 99, pl. 9, fig. 1.

Species relatively small. Brachial valve with distinct median depression along entire length. Pedicle valve with relatively large, diverging hinge-area which causes its beak to stand away from that of the brachial valve. Specimens numerous with forty to forty-five plications of approximately equal prominence; but there are specimens in which twenty to twenty-five of the plications make their appearance within 7 or 8 mm. from the beak, additional plications being intercalated anteriorly, but the primary striæ remaining dominant. This causes some specimens to appear more coarsely plicated than others, but they are regarded merely as more robust individuals. The most conspicuous feature is the concentric striæ which are sharply elevated and nearly equi-distant.

Locality and Horizon. *Hebertella insculpta* was described originally from the Blanchester division of the Waynesville where it occurs both in the top and bottom layers. It is known also a short distance above the base of the Liberty in Ohio. At the Waynesville horizon it occurs in Ohio, Indiana, and Kentucky. In Richmond strata from Tennessee, Illinois, Wisconsin, Minnesota, and Iowa where it tends to be more finely plicated.

In the Girvan district of Scotland, *Glyptorthis* is represented by *Orthis (Hebertella) balclatchiensis* Davidson, from the lowest or Balclatchie stage of the Caradocian formation.

In American strata *Glyptorthis bellarugosa* (Conrad) is widespread in the Black River formation of the upper Mississippi valley, as far south as central Kentucky. A similar form occurs in the Valcour member of the Chazyan on Valcour island, New York.[1]

Glyptorthis insculpta manitoulinensis var. nov.
Plate V, Figure 7

In the Manitoulin Island and Meaford forms of *Hebertella insculpta* the radiating plications are distinctly coarser and less numerous than in the typical forms. For this form the name *Glyptorthis insculpta manitoulinensis* var. nov. is suggested.

Locality and Horizon. Common in the Meaford formation on Manitoulin island, at Gore Bay, Kagawong, south of Little Current, Manitowaning, and Clay cliffs. Also near Meaford, but not recorded so far from Oakville, Streetsville, or any point eastward in either Ontario or Quebec.

Glyptorthis crispata (Emmons)
Plate XXXI, Figure 10

Orthis crispata Emmons, Geol. New York, Rept. 2nd Dist., 1842, p. 404, fig. 5.
Glyptorthis crispata Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 258, pl. 3, fig. 9.

Largest pedicle valve found, 17 mm. long and at least 20 mm. wide, lateral margins not being well preserved on one side. Largest brachial valve found, 12 mm. long and 16 mm. wide. Convexity of pedicle valve 4 mm., and of brachial valve 2 mm. Greatest convexity of pedicle valve about one-fourth length of shell from beak. Cardinal area fully 2·5 mm. in height in larger valves. Muscular area not obcordate, but narrowed anteriorly so as to give the deepest part of the area a rounded rhomboidal form with the greater axis parallel to the length of the shell. Adductor impressions occupying almost one-third of the width of the area, distinctly limited as far as the beak. Anterior to the middle of the adductor impression, is a narrow thickening of shell along the middle line, but this can be traced only a short distance. Laterally and antero-laterally from the muscular area are long and rather distant radiating striæ, as a rule called ovarian markings, but these are rarely preserved.

[1] Anns. of Carnegie Mus., 7, 1911, p. 245, figs. 19, 20.

Brachial valve moderately and rather evenly convex. Cardinal process long, narrow, and thin. Crural plates strongly defined and terminating in sharp points. Anterior to the cardinal process shell thickened so as to produce a low, broad elevation extending slightly farther than the anterior edge of the posterior adductor impressions, which are only faintly delimited; anterior ones not at all, in the specimens at hand.

Surface marked by rather angular plications, increasing by intercalation, about 5 or 6 in a width of 5 mm., along the anterior margin of the shell. Concentric striæ lamellose, varying from eight in a length of 4 mm. near middle of shell, occasionally to twelve in same length near anterior margin.

Locality and Horizon. From Lorraine and Worthville, New York, in the Pulaski member of the Lorraine.

Platystrophia clarksvillensis Foerste

Plate X, Figure 12; Plate XI, Figure 3

Platystrophia clarksvillensis Foerste, Bull. Denison Univ., 16, 1910, p. 65, pl. 3, figs. 4, 3.

Specimens 25 mm. wide occur, but the average is nearer 20 mm. Specimens with nearly rectangular postero-lateral outlines predominate, but in some the postero-lateral angles equal 70 degrees; as a rule, however, only on one side.

Locality and Horizon. Widely distributed in the Waynesville of Ontario. On Manitoulin island it occurs at Gore Bay, Kagawong, south of Little Current, Manitowaning, and Clay cliffs (No. 8508), also at Meaford, Oakville, and Streetsville; in Quebec in the Waynesville at St. Hilaire, in erratic blocks at St. Hugues, in the Nicolet River section, and on Snake island.

The species was described originally from the Waynesville of Ohio, Indiana, and Kentucky.

P. versaillesensis Foerste (Plate X, figure 13) is characterized by great extension of the shell parallel to the hinge-line; otherwise closely related to *P. clarksvillensis*, rather than to *P. acutilirata*.

Recently, Mrs. Eula Davis McEwan has monographed the genus[1] and says the oldest known American species occurs in the Decorah member of Wisconsin. Another species occurs in the Kimmswick member of the Black River of Missouri, from which area it was identified by the present writer as *P. shepardi* (Castelnau).

According to Raymond[2] the genus makes its first appearance in Canada in the Lorette member of the Trenton, where it is represented by three species, two of which are confined to the Lorette. One of these species, *P. champlainensis* McEwan, from Montreal, presents two plications in the sinus, a characteristic of European Ordovician species, instead of three plications as in American Ordovician forms. These species taken in conjunction with species resembling *Dinorthis retrorsa* (Salter) at Ottawa, Belleville, and near L'Orignal[3], and at Snake Hill, Saratoga county, New

[1] "A Study of the Brachiopod Genus *Platystrophia*," Proceedings of the U.S. Nat. Mus., vol. 56, 1919, pp. 383-448, plates 42-52.

[2] Geol. Surv., Can., Mus. Bull. 31, 1921, pp. 17-20.

[3] Geol. Surv., Can., Pal. Foss., 1, 1865, p. 136.

York, suggest a closer relation of this Canadian part of the Trenton with European seas than is shown by the more southern parts of the Trenton in North America.

Plectambonites sericeus Sowerby

Plate XIII, Figures 2 *a*, *b*, and 3

Cf. *Leptæna sericea* Sowerby, Murchison's Silurian System, 1839, pl. 19, figs. 1, 2.

Leptæna sericea Hall, Pal. New York, 1, 1847, p. 287, pl. 79, figs. 3 *a*, *b*.

Small shells, width about twice the length, mostly of moderate convexity, and with numerous very fine, radiating striæ, almost too fine to be seen without a lens.

The name *P. sericeus* has been used until recently to cover almost all American forms referable to the genus. The name *P. curdsvillensis* (Plate XIII, figure 2 *a*, *b*) has been proposed for the forms found in the Curdsville member of the Trenton in Kentucky. The name *P. rugosa* was proposed fifty years ago for the form common in the Southgate member of the Eden formation, Cincinnati. The varietal name *P. rugosa clarksvillensis* (Plate XIII, figure 3) was proposed for the form in the lower third of the Clarksville division of the Waynesville in Ohio. In the absence of any detailed study of the Canadian forms all of the latter are retained provisionally under the old name *sericeus*, although probably not identical with the Caradoc form first bearing that name.

In the Nicolet River section, *Plectambonites* ranges from the base of the *Cryptolithus* zone to the top of the Waynesville, but the Waynesville form differs from the small form found at that horizon on Manitoulin island.

Recently Prof. Kirtley F. Mather proposed the term *P. punctostriatus* for the form in the lower Trenton on Wolfe island.[1]

Forms closely resembling *P. sericeus* occur as low as the Platteville limestone of the northern Mississippi valley and in the Plattin limestone of Missouri, in the lower part of the Black River formation.

Locality and Horizon. Lorraine; *Cryptolithus* zone, at Petite Caroline, and St. Hugues; *Leptæna* zone, at Petite Caroline; *Proetus* zone, at Chambly Canton, Vars, Hawthorne, and Ramsey; *Pholadomorpha* zone, at Weston, Meaford, Clay cliffs, and south of Little Current. In the Waynesville at Vars and St. Hilaire. In the Eden near Clay cliffs.

Plectambonites rugosus manitoulinensis var. nov.

Plate XIV, Figure 4 *a-d*

Comparatively small, largest specimens noted 7 mm. long, 15 mm. wide, convexity 3 mm. Most specimens do not exceed 12 mm. in width. Postero-lateral angles vary from nearly rectangular to 80 degrees, surface striæ very fine; about 8 in a width of 3 mm. are slightly more distinct, intermediate ones seen readily only under a lens. Interiors of both pedicle and brachial valves as in *P. rugosa-clarksvillensis*, from the Waynesville in Ohio and Indiana.

Locality and Horizon. Meaford beds (No. 8557). At Kagawong and 2 miles northeast of Gore Bay, in upper part of the cliff along shore.

[1] Ottawa Naturalist, 31, 1917, p. 38, pl. 1, figs. 15-17.

Plectambonites plicatellus (Ulrich)
Plate XIII, Figure 4 *a*, *b*

Plectambonites plicatella Hall and Clarke, Pal. New York, 8, pt. 1, 1892, pl. 15*a*, figs. 34, 35.

Shells very small, 1·5 mm. long and 3·5 mm. wide. About twenty radiating striæ reach the beak or terminate close to it, and sufficient are intercalated anteriorly to produce about thirty along the margin.

Locality and Horizon. Described originally from the Fulton layer, at the base of the Eden, Covington, Kentucky. Also from the Indian Ladder beds in New York.

Rafinesquina alternata (Emmons)
Plate XIII, Figure 6 *a*, *b*, *c*

Leptœna alternata Hall, Pal. New York, 1, 1847, p. 286, pl. 79, figs. 2 *f-l*.

Under this name it is customary to group a great variety of shells rather large for brachiopods; both valves curved in the same direction leaving little space between them; pedicle valve convex even at the beak; brachial valve concave; surface marked by numerous radiating striæ, alternating in size, often with groups of three or four finer striæ between the larger coarser ones, except toward anterior margin, where alternation in size is more common. Interior of pedicle valve exhibits a large muscle scar, slightly but distinctly impressed in inner surface of shell. This impression somewhat radiately striated, but much larger in size than in *Strophomena*, often exceeding half the length of the shell. Contrasted with *Strophomena*, ventral valve distinctly convex along its anterior border, whereas in *Strophomena* it would appear concave here. In a corresponding manner, brachial valve of *Rafinesquina* distinctly concave anteriorly, instead of somewhat strongly convex.

Rafinesquinæ vary considerably in size, outline, convexity, degree of geniculation anteriorly, coarseness of striation, and other features. Eventually, the genus will be divided into a number of species and varieties.

In upper Ordovician rocks of Ontario and Quebec the flat forms are most common, the more strongly convex forms rare; for instance, in *Proetus* zone at Chambly Canton.

Locality and Horizon. Nicolet River section where it ranges from the top of the *Proetus* zone of the Lorraine to the Waynesville; in the *Leptœna* or *Cryptolithus* zone at Petite Caroline; in the *Proetus* zone in Chambly Canton, the mouth of Huron river, and at Vars; in *Pholadomorpha* zone in the Nicolet River section, and at St. Hilaire, in the so-called Lorraine at Weston, and 3 miles south of Little Current; in the Waynesville on Snake island, in the Nicolet River section, on Huron river, at St. Hilaire, in loose blocks near St. Hugues, at Vars, Streetsville, Oakville, near Meaford, at Clay cliffs, 3 miles south of Little Current, and near Kagawong. It is comparatively rare at the *Cryptolithus* and *Leptœna* horizons in Ontario, and not known in the Kagawong member on Manitoulin island.

Rafinesquina is well represented in the Chazyan, from which four species have been described.

Rafinesquina nasuta Conrad

Plate XXXI, Figure 2 *a*, *b*

Strophomena nasuta Emmons, Geol. New York, Rept. 3rd Dist., 1842, p. 403, fig. 3.
Leptæna alternata Hall, Pal. New York, 1, 1847, p. 286, pl. 79, figs. 2 *a-c*.
Rafinesquina nasuta Foerste, Bull. Sci. Lab. Denison Univ., 14, 1914, p. 263, pl. 3, figs. 2 A, B; pl. 4, fig. 2 C.

Ventral valve gently convex over the body of the shell; strongly, but not abruptly, curved downward along the anterior margin so that its convexity there reaches 7 to 10 mm. In different specimens lateral sides vary greatly, from diverging to converging anteriorly. Anterior to the middle, all shells tend to converge with somewhat straightened antero-lateral sides, and to be produced along the median part of the anterior margin in a nasute manner. This anterior nasute prolongation in many cases springs from a base 17 or 18 mm. wide, but there are numerous specimens with nasute prolongations originating at bases 8 to 10 mm. in width.

Locality and Horizon. The type described by Conrad was found at Rome, New York, at a much higher horizon than the specimens here figured from Pulaski. Lateral sides of this type parallel, and antero-lateral sides meet anteriorly so as to give the general outline of the shell a pentagonal effect. The nasute prolongation anteriorly was barely 3 mm. wide at its base. Figure 2 *a* on Plate 79, of the Paleontology of New York, volume 1, presents an outline very similar to this type.

Rafinesquina mucronata Foerste

Plate XIV, Figure 1; Plate XXX, Figures 6, 7

Rafinesquina mucronata Foerste, Bull. Denison Univ., 17, 1914, p. 265, pl. 2, figs. 7 *a*, *b*.
Cf. *Rafinesquina squamula* Bassler, Cambrian and Ordovician, Maryland Geol. Surv., 1919, p. 264, pl. 54, figs. 3, 4; pl. 58, fig. 4.

Small and short with distinct convexity of shell, considering its small size. Shell as a rule extends slightly along hinge-line so as to produce short mucronate projections. Oblique wrinkling along the hinge-line so frequent as to be almost characteristic, though not invariably present. Usually the striation that lies along the median line is more conspicuous than the rest.

Locality and Horizon. Described originally from the *Pholadomorpha* zone in the Lorraine, Nicolet River section. In this section *Rafinesquina mucronata* makes its appearance at the top of the *Leptæna* zone and ranges through the *Proetus* (No. 8574) and *Pholadomorpha* zones. In the *Proetus* zone at Chambly Canton (No. 8575), Vars, and Hawthorne, and in the *Pholadomorpha* zone at Weston, and Meaford. In the Waynesville at Vars.

In New York state in the shales at Lorraine and at a higher horizon at Pulaski, in both cases associated with *Cryptolithus*. At Petite Caroline either in the *Leptæna* or in the Cryptolithus zone.

Rafinesquina squamula James (Plate V, figure 6). In the Fairmount member of the Maysville, Cincinnati, Ohio, a similar small species occurs, in which the ratio of length to width is 4 to 5, instead of 3 to 5 as in *R. mucronata*. In other words, *R. squamula* is a distinctly longer shell, more readily comparable with the young of *R. alternata*. *R. squamula*, also, is a much more moderately convex shell, with no conspicuous oblique wrinkling along the hinge-line.

Leptæna moniquensis sp. nov.
Plate XIV, Figures 2, 3 *a*, *b*, *c*

Cf. *Leptæna gibbosa invenusta* Foerste, Bull. Denison Univ. 14, 1909, p. 315, pl. 7, fig. 3.
Cf. *Leptæna tenuistriata* Foerste, Bull. Denison Univ., 16, 1910, p. 45, pl. 5, fig. 9.

Main body of shell gently convex, with comparatively low and rather close-set wrinkles. Toward the anterior margin pedicle valve curved strongly downward along a concentric and strongly geniculate line of elevation, usually about 2 mm. wide and raised barely 1 mm. above general convexity of valve posteriorly. Below this limiting geniculate ridge the anterior face of the shell varies from 5 to 7 mm. in height and slopes at 120 to 130 degrees with the general plane of the main body of the valve. At postero-lateral angles, concentric wrinkles tend to meet the hinge-line at approximately right angles, but upper parts of the lateral outlines of the shell extend slightly farther than lower parts, forming small extensions or ears. Radiating striæ numerous, about 15 in a width of 5 mm., thread-like, not prominent, and separated by narrow grooves.

Muscle impression in the interior of pedicle valve shallow, with distinct margins, but only slightly elevated, possibly not more than a fourth or a third of a millimetre. Inner part of the muscle impression overlies a part of shell so thin that radiating striæ on outer surface leave their markings over the greater part of its area. In a specimen 13 mm. long from hinge-line to geniculate border, muscle area 7·5 mm. wide and 6·5 mm. long. Outline nearly round. Markings on interior of brachial valve relatively weak.

Leptæna invenusta Foerste was described from a member of the Cynthiana formation at Drennan Springs, Kentucky, associated with *Cryptolithus;* otherwise this Drennan Springs fauna is quite different from that occurring in Canada. Compared with *L. invenusta*, the Nicolet River specimens are narrower and longer, more strongly geniculate anteriorly, with the concentric wrinkling more conspicuous. Radiating striæ more sharply elevated. These differences are regarded as sufficient to constitute a new species, though the two forms evidently are closely related.

Walcott cited *Leptænæ* from Lorraine material in New York state.

Although *L. richmondensis* is common in the Richmond in Ohio, Indiana, and Kentucky, beginning in the Arnheim and extending to the top of the Whitewater, no specimen has been found in the Richmond of Canada. The *Leptænæ* in the Richmond of the Mississippi valley belong to the *L. unicostata* group.

Locality and Horizon. In the Nicolet River section, *Leptæna moniquiensis* ranges from 488 feet below top of *Cryptolithus* zone upward to top of *Leptæna* zone, a total of 1,057 feet. In *Cryptolithus* zone at St. Hugues, St. Hyacinthe, and Petite Caroline (No. 8560). The figured specimen (No. 8559) was obtained 150 feet below top of *Cryptolithus* zone in Nicolet River section.

Closely similar forms, regarded as same species, occur in the Don Valley brick-yard, Toronto, in the *Cryptolithus* zone of the Lorraine (No. 8558).

Trenton Occurrences. Leptæna of the *tenuistriata* group makes its appearance early in the Trenton. It occurs in the Rysedorph conglomerate near Albany, New York; in *Sinuites* bed of Martinsburg shale, Pennsylvania; at Nepean Point, Ottawa; Clifton, Tennessee, in the Saltillo member of the Trenton.

The genus makes its first appearance in the Chazyan of New York and Mingan islands.

Strophomena planumbona (Hall)

Plate XII, Figure 1 *a, b, c*

Strophomena planumbona Hall and Clarke, Pal. New York, 8, pt. 1, 1892, p. 251, pl. 9, figs. 15-17; pl. 9 A, figs. 8, 9.
Strophomena planumbona Foerste, Bull. Sci. Lab. Denison Univ., 17, 1912, p. 73, pl. 8, figs. 1 *a-e;* pl. 9, figs. 3 *a, b*; pl. 4, figs. 1-4.

Shell rather small, with subquadrangular outline, anterior broadly rounded; pedicle valve usually curved downward only moderately toward its anterior margin; surface striæ fine; muscle impression in interior of pedicle valve having high border along its entire margin, except anteriorly where the border is open, its anterior parts, on each side of median line curving slightly forward; callous thickening along anterior margin of valve narrow, and crossed radially by vascular markings. Some shells are more prolonged along hinge-line and some have oblique wrinkles along this line.

Locality and Horizon. Type locality probably from Waynesville, Oxford, Ohio. It ranges at this horizon through Ohio, Indiana, and Kentucky. Common in lower half of Liberty in all three states. Rare in Ontario and Quebec, though closely similar specimens are widely distributed, but scarce.

On Manitoulin island specimens of this type occur in the Waynesville member at Gore Bay, Kagawong, on Bass Lake road south of Little Current, and at Clay cliffs; southeast of Meaford; Oakville and Streetsville. In the province of Quebec, in Huron River section; in erratic blocks at St. Hugues, and in situ at St. Hilaire and in the Nicolet River section.

Strophomena planumbona gerontica (Plate XII, figure 6 *a, b*). A single specimen of the gerontic form of *S. planumbona*, much thickened interiorly and along the hinge-line, west of Gore Bay (Plate XII, figure 6 *c*).

Strophomena manitoulinensis. Most specimens of *Strophomena* on Manitoulin island and along the south shore of Georgian bay belong to the more triangular form for which the name *S. manitoulinensis* is proposed.

In certain parts of Quebec, the genus is represented in the *Pholadomorpha* zone by specimens belonging to the *S. planumbona* group, or by closely similar forms. They are fairly common in this zone at the bend of Huron river, near its mouth (No. 8405). These specimens, however, tend to be more triangular in outline, and more prolonged along the hinge-line. Specimens of *Strophomena*, labelled from Chambly village (No. 8404), may have come from the *Proetus* horizon.

Strophomena planumbona chambliensis Foerste

Plate XXX, Figures 4, 5

Strophomena planumbona var. Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 260, pl. 2, figs. 4 A, B.

Shell resembling *Strophomena elongata* James in its elongation along hinge-line, but differing in its greater length, greater convexity, especially anteriorly, outline tending to be subtriangular.

Locality and Horizon. Lorraine: *Proetus* zone, Chambly Canton (No. 8404). Also from Huron river (No. 8405).

Strophomena nutans Meek

Plate XII, Figure 2 *a-d*

Strophomena nutans Hall and Clarke, Pal. New York, 8, pt. 1, 1892, p. 251, pl. 8, fig. 11; pl. 9 A, figs. 5-7; pl. 11 A, figs. 6, 7.
Strophomena nutans Foerste, Bull. Sci. Lab. Denison Univ., 17, 1912, p. 68, pl. 3, figs. 2 A-E; pl. 9, fig. 15; pl. 10, figs. 2 A-C; pl. 11, fig. 8.

Shell commonly narrower, but some same width as *S. planumbona;* distinctly longer and usually more or less prolonged along the median line, so as to produce a nasute or sub-triangular outline; callous thickening along anterior margin of interior of the pedicle valve broader and more conspicuous, especially along median parts of the valve, and here the vascular markings usually are more irregular. Although smaller, the valves usually are thick, suggesting gerontic characteristics, a feature also suggested by the more conspicuous callous thickening.

Locality and Horizon. Common in the Blanchester division, Waynesville member, Ohio and Indiana. A single but typical fragment in the Meaford, Clay cliffs (No. 8127).

Nasute forms, elongated along median line anteriorly, occur at many horizons. *Strophomena trilobita* (Owen), from Trenton of the upper Mississippi valley and of southern Canada[1] is such a form, but the very gerontic thickening of interior of shell is characteristic of *S. nutans*.

Strophomena huronensis Foerste

Plate XIII, Figure 1 *a-j*

Strophomena concordensis huronensis Foerste, Bull. Sci. Lab. Denison Univ., 17, 1912, p. 63, pl. 11, figs. 1 A-K.

General outline of shell subnasute and subpentagonal. In some specimens this is strongly marked; in others the convexity of the shell

[1] Geol. Surv., Can., Mem. 31, 1921, Pl. VII, fig. 6.

more regular, and general outline about as evenly rounded as in *S. planumbona*. However, shells in which subnasute outline is only faint are more common. Postero-lateral angles commonly vary between 80 and 85 degrees, but mostly rectangular, and some may be as acute as 70 degrees. Shell extended at hinge-line.

Brachial valve flattened posteriorly for about 10 mm. from the hinge-line, beyond which the downward curvature of the valve begins. Maximum convexity as a rule located 12 to 15 mm. anterior to beak. In subpentagonal shells, the slope from here to the antero-lateral margins more rapid than along median line, thus giving central part of valve a slightly humped appearance. Downward curvature of shell mostly rather regular anteriorly, but in some quite abrupt. In some shells nasute character very pronounced; an individual may be found in which the nasute character is as prominent as in the figure of *S. hecuba* published by Billings.[1]

Pedicle valve rather strongly concave, especially in the more nasute specimens; frequently equalling 3 or 4 mm. in shells 22 to 30 mm. long. Immediately anterior to beak, valve is distinctly convex, the reversal of curvature taking place between 12 and 15 mm. from the beak. So many of the shells are obliquely wrinkled along the hinge-line that this feature may be said to be characteristic of the species, though this wrinkling is in many of them inconspicuous or absent. Angle between wrinkles and hinge-line varying between 30 and 40 degrees.

Radiating striæ on the surface usually between 12 and 13 in a width of 5 mm., but may range from 10 to 15. Striæ commonly alternately large and small, but three finer striæ may alternate with one stronger one; the stronger striæ usually not very prominent.

Callous thickening along anterior margin of interior of the pedicle valve moderate, rarely exceeding 2 mm., crossed by radiating vascular markings of no great depth. Compared with *S. planumbona*, this callous thickening is broader in a direction lengthwise to the shell.

Chief difference between this species and *S. concordensis* is the frequent presence of the oblique wrinkles. On that account *S. huronensis* may be regarded as a variety of *S. concordensis*.

Locality and Horizon. Common in the Meaford, Clay cliffs. Also at the same horizon at Wekwemikongsing, 3 miles south of Little Current, near Kagawong, and Gore Bay, and southeast of Meaford.

Strophomena fluctuosa Billings
Plate XII, Figure 8 *a, b*

Strophomena fluctuosa Billings, Pal. Foss. 1, Geol. Surv., Can., 1865, p. 123, fig. 102.

Shells have a tendency toward a triangular or pentagonal form, but not always very pronounced. Also a tendency toward oblique wrinkling along hinge-line, with interrupted wrinkling on posterior flat part of the valve. These interrupted wrinkles, in a general way, arranged concentrically, but there is zigzag crossing in some specimens, as in the figured type. Radiating striæ very fine on posterior flatter half of the brachial

[1] Pal. Fossils, vol. I, p. 126.

valve, but anteriorly some striæ become more prominent, so that five to seven striæ occur between the stronger ones, or perhaps only three or four of these finer striæ in cases where one of the intermediate striæ of the larger group has become more prominent anteriorly. About seventeen to twenty of these stronger striæ extend back as far as beak. Anteriorly, ten to sixteen striæ occur in a width of 2 mm. Along the strongly descending anterior margin of the brachial valve there may be only two finer striæ between a pair of stronger ones, or finer and coarser striæ may alternate locally.

Muscle impression on the interior of the pedicle valve of the *S. planumbona* type. Thickening along anterior margin of the pedicle valve, interiorly, inconspicuous and crossed by radiating vascular markings similar to those in *S. huronensis*.

Locality and Horizon. Described and figured from Anticosti island, from the English Head, Vaurial, and Ellis Bay members of the Richmond. In Waynesville, southwest of Vars.

Billings states this species rare in Trenton, Ottawa, but no collections made there since show typical specimens of *S. fluctuosa*, and probably some form of *S. deltoidea* was at hand.

The *fluctuosa* type of Strophomena appears to be of North Atlantic dissemination, similar forms occurring also in Scandinavian strata.

Strophomena vetusta (James)

Plate XII, Figure 4 *a, b;* Plate XIV, Figure 5

Strophomena vetusta Foerste, Bull. Sci. Lab. Denison Univ., 17, 1912, p. 98, pl. 6, figs. 2 A-H.

Strophomena vetusta is intermediate in size between *S. planumbona* and *S. neglecta*. It belongs to the *S. planumbona* group, in which muscle impression of pedicle valve is bordered laterally by a fairly strong rim, whose anterior parts separate and curve forward, leaving a median gap. Thickening along anterior margin of this valve usually inconspicuous; outline of shell tending to be quadrangular, and surface usually wrinkled somewhat steeply along hinge-line. Surface of pedicle valve very finely striated radially and more or less finely wrinkled concentrically. The surface of the brachial valve, on the contrary, is conspicuously more coarsely striated than in *S. planumbona* or *S. neglecta*.

Locality and Horizon. Described from the Whitewater member of Ohio, Indiana, and Kentucky. Occurring also in upper half of Liberty. Preceded by a form almost identical with typical *S. vetusta*, but with slightly finer radiating striæ on brachial valve, in the Blanchester division of the Waynesville, Ohio and Indiana, and in Lewis, Fleming, and Bath counties in Kentucky. This earlier form has been called *S. vetusta precursor* (Plate XII, figure 3 *a, b, c*).

S. vetusta is found in the Richmond at Stonington, Mich.; also along the northern shore of Drummond island, in strata equivalent to the Whitewater member of the Richmond. Several specimens were found 3 miles south of Little Current between concessions IV and V, directly above the *Stromatocerium* and *Columnaria* reef; the only known Canadian locality. Largest specimen 21 mm. long and 27 mm.

wide, brachial valve having a convexity of 4 mm. Radiating striæ comparatively strong along marginal parts of brachial valve, becoming less conspicuous toward its middle part. Anteriorly, finer striæ in many cases alternate with coarser. Posteriorly they are more nearly alike in size. Of the stronger striæ, nine usually occur in a width of 5 mm., their number depending upon the size of the intermediate finer striæ. Along the hinge-margin, laterally, are nearly vertical wrinkles (No. 8556) Plate XIV, figure 5.

Strophomenæ of the *vetusta* group are represented in the middle Trenton, Peterborough, by *S. foveata* Raymond.[1]

Strophomena neglecta (James)

Plate XIII, Figure 5 *a*, *b*

Strophomena neglecta Foerste; Bull. Sci. Lab. Denison Univ., 17, 1912, p. 90, pl. 5, figs. 1 A-B; figs. 3 A-F; pl. 7, fig. 5; pl. 9, figs. 1 A-C; fig. 10; pl. 11, fig. 10.

Strophomena neglecta belongs to the *S. incurvata* type in which the muscle impression in the pedicle valve is rotund, with relatively low border, surface within impression being marked radially by flabellate lines. Thickening along the margin of this valve relatively inconspicuous. Compared with *S. planumbona,* the shell is much larger and surface striæ even finer. Anterior outline broadly rounded, posterior part as a rule somewhat prolonged at the hinge-line. Downward curvature of anterior part of brachial valve in some places considerable, but never as in typical *S. hecuba.*

Locality and Horizon. Blanchester division of the Waynesville, southwestern Ohio; southeastern Indiana; Lewis, Fleming, and Bath counties, Kentucky.

Similar specimens occur in the Richmond formation at Stonington, Mich., and on Manitoulin island, a typical specimen was found immediately south of Kagawong, the only specimen known from Canada.

Strophomenæ of the *neglecta* type are abundantly represented in the Mohawkian strata of North America by *S. incurvata* (Shepard), described also by Hall from the Trenton of New York as *S. filitexta.*

Strophomena hecuba Billings

Plate V, Figure 4; Plate XII, Figure 7 *a*, *b*

Strophomena hecuba Billings, Pal. Foss. 1, Geol. Surv., Can., 1865, p. 126, fig. 104.

Strophomena hecuba is a relatively large species that also belongs to the *S. incurvata* type, having a round muscle impression in the pedicle valve, with relatively low border, the surface of the impression marked by radiating flabellate striæ. Anterior part of brachial valve of *S. hecuba* curves strongly and rather evenly downward. Striæ fine, seven to ten in a width of 2 mm. along anterior margin of shell. Type figured by Billings was triangular or nasute in form; other specimens from type locality vary considerably in form, some being regularly rounded along anterior margin and not nasute.

[1] Geol. Surv., Can., Mem. 31, 1921, Pl. VII, fig. 4.

In the Nicolet River section, nine-tenths of the specimens found are triangular, and prolonged along median line in a nasute manner, as in many of the Anticosti specimens, but radiating striæ are coarser than in the latter, only five, but in some cases seven, occurring in a width of 2 mm.

S. hecuba most abundant 40 feet above the highest horizon containing *Catazyga headi*, and found at intermediate intervals. At its lowest horizons associated with *S. sulcata*. It may be regarded as northeastern representative of *S. neglecta*.

Locality and Horizon. Originally described from Anticosti island, in the English Head, Vaurial, and Ellis Bay members of the Richmond formation (No. 2016 A).

An impression of the interior of the brachial valve of some unknown species of *Strophomena* was found in the Nicolet River section about 10 feet below the top of the *Proetus* zone of the Lorraine. It was 27 mm. wide and resembles *S. hecuba* in size and in a tendency toward triangulation, but nothing is known of the ornamentation of its exterior surface, and it may belong to a distinct species, especially since it occurs far below the lowest horizons regarded as of Richmond age (Plate XI, figure 8) (No. 8571).

The genus is known in the United States already, from the Chazyan. The *planumbona* group is well represented in the Trenton.[1]

In Quebec it occurs in the Waynesville of the Nicolet River section, at Huron river, at St. Hilaire, and in erratic blocks near St. Hugues.

Holtedahlina

Holtedahlina gen. nov.

Schuchert distinguished two groups of *Strophomena*: (1) those in which the pedicle valve is concave anteriorly and antero-laterally, and (2) those in which the convexity of the umbonal part of the pedicle valve continues almost or altogether as far as the anterior margin, though in a diminishing degree.

In the second group he included those in which the median part of the brachial valve tends to be elevated into a somewhat conspicuous fold anteriorly, and the corresponding part of the pedicle valve tends to be depressed into a sinus. The latter are here selected as the more typical forms of the proposed new generic group *Holtedahlina*, with *Strophomena sulcata* Verneuil as the genotype. This species is characterized by relatively coarse, radiating striæ, coarse enough to be called plications, and the anterior part of the muscle scar of the pedicle valve is weakly defined.

S. sinuata Meek, a closely similar species, occurs in the middle of the Fairmount and *S. sulcata* ranges from the Clarksville division of the Waynesville to the top of the Whitewater group, but the former may not be ancestral to the latter, since the anterior fold and sinus may have originated independently in a number of species from ancestors more nearly resembling *S. planoconvexa* Hall. *S. sinuata*, at least, appears to have originated directly from *S. planoconvexa*, whereas the immediate ancestors of *S. sulcata* are unknown. Both *S. sinuata* and *S. sulcata* have coarse, radiating striæ and weakly defined muscle scars.

[1] Geol. Surv., Can., Mem. 31, 1921, pl. VII, fig. 3.

Strophomena scofieldi Winchell and Schuchert, from the Prosser member of the Trenton of the upper Mississippi valley, resembles the preceding in having a median fold and sinus, but the radiating striæ are much finer. It may not be as closely related as its general form suggests, but, for the present, it is regarded as possible that the more coarsely striated species originated from the more finely striated ones, and *S. scofieldi* is regarded as an early form of *Holtedahlina.*

Provisionally *S. planoconvexa* Hall and *S. maysvillensis* also are included in *Holtedahlina,* being regarded as ancestral to *S. sinuata. S. maysvillensis* ranges from the lower Mount Hope to the upper Fairmount in various parts of Kentucky, and *S. planoconvexa* appears merely to be a local depauperated variety of the former, confined to a single layer between the top of the Mount Hope and the base of the Fairmount. The convexity of the median part of the brachial valve of *S. maysvillensis* anteriorly, with a corresponding concave flexure of the pedicle valve, appears to be preliminary to the median fold and sinus of *S. sinuata. S. planoconvexa, S. maysvillensis,* and *S. sinuata* agree in the coarseness of the radiating striæ and in the character of the muscle scar of the pedicle valve.

Strophomena hallie, Miller, from the Economy and Southgate members of the Eden, is less coarsely striated than typical *S. maysvillensis,* but may be regarded as intermediate between *S. scofieldi* and *S. maysvillensis.* In its tendency toward a nasute form, it simulates *S. maysvillensis* more closely than *S. planoconvexa.*

In the same manner as *S. sinuata* may be regarded as a derivative of *S. maysvillensis, S. millionensis* may be a derivative of the same stock as *S. hallie.*

Schuchert regarded *S. scofieldi* as closely related to *S. billingsi* Winchell and Schuchert, though the latter has a less defined sinus and fold, finer radiating striæ, and concentric growth lines more delicate and closely crowded.

Species resembling *S. sulcata* in having a median fold and sinus, and coarse, radiating striæ, are figured by Holtedahl from the Christiania area. They appear to have a wide range in northern areas. In Canada, *S. sulcata* occurs on Manitoulin island, and similar forms occur in the Ottawa basin and as far northeast as lake St. John.

Among the forms figured from the Girvan district of Scotland, *S. antiquata woodlandensis* Reed[1] may belong here.

Holtedahlina sulcata (Verneuil)

Plate XII, Figure 5 *a, b*

Strophomena sulcata Hall and Clarke, Pal. New York, 8, pt. 1, 1892, pl. 9, figs. 8, 9; pl. 11 A, fig. 8.

Strophomena sulcata Foerste, Bull. Sci. Lab. Denison Univ., 17, 1912, p. 102, pl. 1, figs. 4 A-C; pl. 11, figs. 2 A-B.

Shell small; coarser striations than any other *Strophomena* in the Richmond. Median part of the pedicle valve depressed into a broad sinus anteriorly, corresponding part of brachial valve raised into a low, median fold.

[1] Trans. Roy. Soc. Edinburgh, 51, pt. IV, No. 26, 1817, pl. XVIII, figs. 20, 21; pl. XIX, figs. 1-5.

Locality and Horizon. Richmond formation from Clarksville division of the Waynesville to top of the Whitewater, but absent at intervals. In the Waynesville it occurs in Ohio and Indiana; in the Whitewater in Kentucky. Its southernmost range known is Dismukes, Sumner county, Tennessee, in the Waynesville. At Stonington, Michigan, in the Waynesville; in Canada, but only in the Meaford, on Manitoulin island, at Kagawong, and at several localities south of Little Current. In the lower, Lorraine-like phase of the Waynesville at Streetsville. Related forms occur at Vars, and on Snake island.

Holtedahlina sulcata moniquensis var. nov.
Plate XI, Figure 7

Pedicle valve distinctly elevated for a short distance anterior to the beak; without distinct median depression anteriorly. Postero-lateral angles incurved, rather than rectangular or projecting. Plications about as numerous as in typical *Strophomena sulcata.*

These Snake Island specimens evidently belong to the *S. sulcata* group. Distinguishing features are the absence of distinct depression along the median part of pedicle valve anteriorly, and of median elevation along corresponding part of brachial valve, elevation of umbonal part of pedicle valve anterior to beak, and reduced angularity of postero-lateral corners of the shell.

Locality and Horizon. Snake island, in the Richmond (No. 8519).

Holtedahlina varsensis sp. nov.
Plate XI, Figure 6

Brachial valve with distinct median fold anteriorly, indicating affinity with *S. sulcata,* but radiating plications few and distant from each other. Postero-lateral angles appear rounded.

Although the specimen figured is somewhat exfoliated, it is quite evident that the plications are farther apart than in typical *S. sulcata.*

Locality and Horizon. From loose blocks of limestone regarded as of Waynesville age, a third of a mile north of the railway, and a mile west of Vars east of Ottawa. In the Richmond formation (No. 8572).

Rhynchotrema capax (Conrad)
Plate X, Figure 16 *a, b*

Atrypa capax Conrad, Jour. Acad. Nat. Sci. Philadelphia, 8, 1842, p. 264, pl. 14, fig. 21.
Rhynchotrema capax Hall and Clarke, Pal. New York, 8, pt. 2, 1893, pp. 183, 185, pl. 56, figs. 14-18, 20-27; pl. 83, fig. 31.

Typical Form. The type of *Rhynchotrema capax* illustrated by Conrad was a very obeseherontic form, such as occurs in the Whitewater at Richmond, Indiana. This type was considerably more gibbous than any other specimen figured since, though similar specimens are common in the Whitewater in Indiana and Ohio. Conrad's figure represents a lateral view. Distance from the beak to the anterior margin of the shell

23 mm.; maximum thickness from pedicle to brachial valve 26 mm., convexity of pedicle valve 12 mm., that of brachial valve 14 mm. The most conspicuous feature of this lateral view is the flatness of its outline along anterior part of shell, due to the strong, almost geniculate curvature of thé shell toward its anterior margin, especially in pedicle valve.

Although it is customary to identify as *R. capax* the various specimens of *Rhynchotrema* in the Richmond of Ontario and Quebec, none has the characteristic obese aspect of the Whitewater type, but they resemble more closely the unnamed forms found in the Waynesville in Indiana and Ohio. Occasionally these Waynesville forms have been identified as *R. perlamellosum*, which also is different.

R. increbescens (Hall) from the Trenton (Plate X, figure 15), is a much smaller species, less gerontically incurved.

A form resembling *R. capax*, found south of the west end of lac Calvaire, 12 miles southwest of the city of Quebec, was listed as *R. increbescens* solely on account of its occurrence in strata apparently as low as the lower Eden of Cincinnatian areas. However, its resemblance to *R. capax* was startling to one accustomed to regard the latter species as a safe index fossil for the Richmond. Unfortunately the Lac Calvaire specimen was found in a soft shale that crumbled before it was photographed or preserved.

Rhynchotrema perlamellosum (Whitfield)

Plate XI, Figure 5 *a, b*

Rhynchonella perlamellosa Whitfield, Geol. Wisconsin, 4, 1882, p. 265, pl. 12, figs. 23-25.

Typical Specimens. Valves, though strongly convex, not gibbous or gerontic. Along lateral margins, the line of junction between valves somewhat angular. Concentric striæ commonly more distinct and at greater intervals than in typical *R. capax*. The types were figured by Whitfield from the Richmond of Delafield and Iron Ridge, Wisconsin. Here the Fernvale type of the Richmond occurs, carrying a fauna quite distinct from any part of the Richmond in Ohio, Indiana, and Kentucky. The Fernvale fauna has not been found in Ontario or Quebec.

Waynesville Specimens. In the Waynesville of Ohio, Indiana, and Kentucky, is a form, usually identified as *Rhynchotrema capax*, resembling *R. perlamellosum* in more moderate convexity and in more prominent and more distant concentric striæ. Compared with the types of *R. perlamellosum* figured by Whitfield, the valves of the Waynesville specimens are more convex, but similar more convex specimens are known from the Fernvale in the Mississippi valley.

The Canadian specimens resemble these Waynesville specimens more than they resemble the typical *R. capax* of the Whitewater member and hence are referred to this species provisionally.

Locality and Horizon. On Manitoulin island, the species of *Rhynchotrema* resembling *R. perlamellosum* occurs in the Meaford member northwest of Kagawong. Common in the *Stromatocerium* and Coral reef at the base of the Kagawong division of the Richmond, at Gore Bay (No.

8511), near Kagawong, and west of the Indian village 3 miles southwest of Little Current. Northwest of Manitoulin island it occurs also farther up in the Kagawong member.

No specimen of *Rhynchotrema* has been found in the Richmond either south of Georgian bay or north of lake Ontario.

In Quebec, *R. perlamellosum* occurs in the lower Waynesville, St. Hilaire.

Rhynchotrema pulchellum sp. nov.

Plate XV, Figure 5 *a, b, c*

Specimens small. Average length 6·5 mm., width 6·5 mm., thickness 4·5 mm. Pedicle valve with shallow median sinus, not strongly differentiated from lateral parts of valve. Brachial valve moderately elevated along its middle, but without a distinct fold. Both valves rather evenly convex. Beak of ventral valve apparently lifted away from that of brachial valve, so as to expose the foramen. Radiating plications varying from twenty to twenty-five in different specimens.

Lifted beak of pedicle valve has aberrant aspect for a *Rhynchotrema*, but the writer knows no other genus to which it appears allied.

Locality and Horizon. From the Waynesville of Snake island (No. 8590).

Rhynchotrema (?) *tamarackensis* sp. nov.

Plate XV, Figure 7 *a, b*

Specimens from 4 to 7 mm. long; width a little less to a little more than length, probably depending upon the degree of compression of the valve during fossilization. The largest valve is 8·5 mm. wide and appears to have been only moderately convex. It apparently has a median plication, on each side of which are four lateral plications successively smaller. The median plication curves slightly farther downward than the adjacent ones, suggesting a faint mesial sinus. This valve is assumed to be the pedicle valve, although its beak is not preserved. Brachial valve appears to be more convex, and to have the four central plications about equally spaced, with the two middle plications slightly more elevated anteriorly. There are two more plications, at successively smaller intervals, on each side. Crests of the plications $\frac{1}{3}$ mm. wide, and rising from 0·5 to 0·75 mm. above the lowest part of the intermediate grooves, which appear to be evenly concave rather than angular.

It is not certain, however, that the specimens belong to *Rhynchotrema*. The plications are about as numerous as in *R. dentatum*, but there is no distinct mesial sinus or fold, and the plications and grooves do not show a similar degree of angularity. It is described chiefly on account of its occurrence in Eden strata, where forms of this type previously were unknown.

Locality and Horizon. From the Sheguiandah shale north of Tamarack point, about 10 miles southwest of Little Current.

Zygospira kentuckiensis James

Plate X, Figure 20 *a, b, c*; Plate XV, Figures 1 *a-p*; 2 *a, b*; 4 *a, b, c*

Zygospira kentuckiensis Hall and Clarke, Pal. New York, 8, pt. 2, 1895, pl. 54, figs. 11, 15, 16.

Zygospira kentuckiensis appears to be larger and more vigorous than *Z. modesta* (Plate X, figure 21 *a, b*) with a tendency on the part of both plications and grooves to be more nearly equal in size, especially along median parts of both valves.

Four plications occupy flattened median part of pedicle valve, and from flattened part the shell slopes away laterally rather angularly. Median groove, along middle of flattened area, slightly broader than other grooves, but in many difference is almost imperceptible. About eight lateral plications on each side of flattened part. Brachial valve convex posteriorly, but anteriorly there is a broad and shallow median depression. Specimens attain a length of 13 mm. and a width of 15 mm.; but average a length of 11 mm., and width of 12·5 mm.

Locality and Horizon. Clay cliffs, Manitoulin island in Meaford (No. 8512), 2 miles southwest of Wekwemikong; in the gully north of the lighthouse of Manitowaning; southwest of McLean hill in the open field 3 miles southwest of Little Current; south of Kagawong; and on the hillside west of Gore bay.

Specimen No. 8506 is intermediate between *Z. kentuckiensis* and *Z. meafordensis.*

Zygospira modesta (Hall)

Plate X, Figure 21 *a, b*

Atrypa modesta Hall, Pal. New York, 1, 1847, p. 141, pl. 15, fig. 15.

Zygospira modesta Hall and Clarke, Pal. New York, 8, pt. 2, 1893, p. 155, figs. 146-149; pl. 54, figs. 7-10, 12.

Zygospira modesta Foerste, Bull. Sci. Lab. Denison Univ., 16, 1910, p. 29, pl. 2, figs. 15 A, B.

Type specimen 7·8 mm. long, 9·2 mm. wide, and 4·1 mm. thick. Pedicle valve has eighteen distinct plications, and two indistinct ones, the latter being near the hinge-margin. The four median plications, moderately elevated above the general convexity of shell, and forming a low, median elevation. Groove along median line of elevation wider than the two adjacent grooves. Corresponding to the median groove, brachial valve has a comparatively strong median plication; the two adjacent plications, one on each side, are narrower. A broad, but shallow depression extends from near the beak to the anterior margin of shell; lateral borders not sharply defined, but formed approximately by the third plication on each side of the median plication. Characterized by low, median fold, and many lateral plications, all primary. In the type there are seven of these on each side, but many have eight and even nine. Some specimens are 10 mm. long.

Large specimens of *Zygospira* have been figured recently by Raymond from the Collingwood shale at Cragleith, Ontario.[1] For these the

[1] Geol. Surv., Can., Mem. 31, 1921, p. 28, pl. VIII, figs. 1-5.

term *Z. raymondi* here is suggested, regarding it as a new species. In the Nicolet River section, this species attains a length of 11 mm., and a width of 14 mm. It differs from typical *Z. kentuckiensis* in being less distinctly flattened along median part of pedicle valve, and, therefore, in being less angular on the lateral margins of this flattened area, where the lateral slope of the valve starts downward (No. 8513).

Typical Specimens. *Z. kentuckiensis* was described by James from the Waynesville in Oldham and Jefferson counties, Kentucky, where it is very abundant locally. It occurs in the Clarksville at Clarksville, Ohio.

Locality and Horizon. Described from the Cincinnatian formation at Cincinnati, Ohio, where typical specimens occur in the Fairmount, but it appears to range from the lower Eden to the upper Richmond. Abundant in the Waynesville member of Quebec.

Zygospira meafordensis sp. nov.

Plate XV, Figure 3 *a, b, c*

Species attaining a length and width of about 13 mm., but as a rule exceeding 10 mm. In form closely similar to *Z. kentuckiensis,* but with more radiating plications, commonly twenty-six to thirty on each valve. Flattening along the median part of the pedicle valve less distinct and there is a tendency toward six, instead of four, plications. Angularity between flattened area and lateral slopes of shell less than in *Z. kentuckiensis.* Median groove along this area usually only slightly more distinct than the other grooves. Umbonal part of brachial valve more convex, and convexity of posterior half more even than in the Kentucky species. Anteriorly, median depression broad and very shallow. The median plication in this depression only slightly more distinct than the others.

Brachial valve has a bilobed cardinal process, on each side of which is a distinct cavity for reception of teeth from pedicle valve. Lobes of cardinal process diagonally rhombic, and grooved along their middle parallel to longer axis.

Locality and Horizon. Queenston member. Concession VIII, lot 24, about 4 miles northwest of Meaford (No. 8514). At the crossroad along lot 36, concession VIII, half a mile south of the east end of Mountain lake, about 1½ miles west of Cape Rich, Grey county, Ont., and 8 miles northwest of Meaford.

Catazyga headi (Billings)

Plate X, Figure 17 *a, b*

Athyris headi Billings, Pal. Foss., 1, Geol. Surv., Can., 1865, p. 147, fig. 125.

Catazyga headi Hall and Clarke, 8, pt. 2, 1893, p. 158, fig. 151; pl. 54, figs. 24-26, 30.

Outline oval-oblong, strongly and evenly convex, except toward the beak where the umbo may be carinated. In some an obscure median groove extends from anterior edge of pedicle valve to within one-third of length of valve from beak, but in many it is absent, and in some a similar groove is seen along the brachial valve. Surface marked by numerous, very fine, moderately elevated, radiating striæ, of which eight to ten occur in width of 4 mm.

Type Specimens. From the Waynesville member of Richmond drift, opposite Three Rivers, Que.

Variety borealis (Plate X, figure 19). Accompanying the original description of *Catazyga headi* is that of its variety *borealis*, described by Billings from pieces of limestone thrown up by the waves on the south-eastern shore of Snake island, from some ledge below water-level. Actual exposures at this locality consist of the Coral zone immediately over typical Waynesville. The types were obtained from the Waynesville itself. The specimens figured by Billings from Snake island were more elongate in outline and had a more tumid umbo than his species types from opposite Three Rivers. But material secured by the writer from Snake island shows that the specimens cannot be distinguished from the Three Rivers types even as a variety when more than a few selected specimens are at hand.

Variety *anticostiensis*. Accompanying the original description of *C. headi*, is also one of the variety *anticostiensis*, described from the English Head member of the Richmond formation on Anticosti island. This is figured as a smaller shell, more rotund in outline. It is listed also from the Vaurial member, and has a total range, according to Twenhofel, of 320 feet on the south shore, and 430 feet on the north shore.

Nicolet River Section. In the Nicolet River section, *Catazyga* has a total vertical range of 1,940 feet, the lowest specimen found in the Lorraine 490 feet below the top of the *Cryptolithus* zone, and 225 feet below the horizon at which *Triarthrus becki* occurs. The specimens are not preserved sufficiently well to determine their species. At the top of the *Cryptolithus* zone is a layer containing specimens of *Catazyga* which have a broadly flattened median zone on pedicle valve similar to that of *Catazyga erratica* (Hall). *Catazyga* is very rare 85 feet farther up, in the lower part of the *Leptæna* zone. It has not been recorded from the upper 525 feet of the *Leptæna* zone, but is abundant throughout the *Proetus* zone, which totals 287 feet, and from which it is identified as *Catazyga headi* and not as *Catazyga erratica*. *Catazyga headi* is widely distributed also in the *Pholadomorpha* zone, which has a total thickness of 455 feet. *Catazyga headi* ranges through the lower 142 feet of the Waynesville member.

Several specimens from the *Proetus* zone on Nicolet river are at hand in which pedicle valve is rather evenly convex, with a slight tendency toward elevation along median line, especially toward the beak, and with no tendency toward flattening along this line, as in *C. headi*. Brachial valve moderately convex, and shows no strong, broad, mesial depression anteriorly, as in *C. erratica*. These specimens should be classed with *C. headi* and not with *C. erratica*.

Similar specimens, resembling *C. headi* in even convexity of pedicle valve, occur in the *Proetus* zone on Richelieu river at Chambly Canton.

A special study should be made of *Catazyga* in the horizons in Quebec and Ontario if its various forms are ever to be of service in stratigraphically distinguishing the horizons.

Locality and Horizon. In the *Cryptolithus* zone, undetermined species of *Catazyga* occur in the Nicolet River section, also at Petite Caroline, St. Hugues, St. Hyacinthe, and at the Don brick-yard, Toronto. In the *Proetus* zone, *Catazyga* occurs at Chambly Canton, Hawthorne, and Ramsay. In the *Pholadomorpha* zone, *Catazyga* occurs at Weston, near Toronto.

In the Waynesville member *C. headi* is found at Snake island, the Nicolet River section, Huron river, St. Hilaire, St. Hugues (loose), Vars, Streetsville, Workman brook near Meaford, Bass Lake road south of Little Current; at Kagawong falls.

In southwestern Ohio and southeastern Indiana *C. headi* is fairly common in the basal part of the Blanchester division of the Waynesville member and in the underlying part of the Clarksville division.

Catazyga (*Orthonomaea*) *erratica* (Hall)

Plate X, Figure 18 *a, b, c*; Plate XV, Figure 6 *a, b*

Orthis ? *erratica* Hall, Pal. New York, 1, 1847, p. 288, pl. 79, fig. 5 *a-f*.
Catazyga erratica Hall and Clarke, Pal. New York, 8, pt. 2, 1893, p. 158, pl. 54, figs. 17-23.

Pedicle valve strongly convex, especially toward umbones; beak strongly incurved, overlapping slightly beak of brachial valve; median part of valve flattened, especially anteriorly, the width of this flattened area at anterior margin exceeding one-third of maximum width and almost equalling half the width of shell. Frequently this flattened area tends to be slightly concave medially, and the change of slope between the flattened and the lateral areas of the valve tends to be angular. Brachial valve convex posteriorly and laterally, but, medially, concave, especially toward anterior margin where the width of concave area equals about two-thirds that of the shell. General convexity of brachial valve distinctly less than that of pedicle valve. Angular borders of the depression diverge at an angle of about 40 degrees, the bottom of this depression tends to be flat for a width corresponding to that of the flattened area along the median part of the pedicle valve. Radiating striæ on the surface of the shell as in typical *Catazyga*.

Locality and Horizon. *Catazyga erratica* was described by Hall from loose blocks of limestone from the Pulaski member of the Lorraine, found either in Wayne or Monroe county, along the shore of lake Ontario. As there are no exposures of Pulaski strata in these counties, the types of *C. headi* must have been transported by glacial action. Judging from the path of the Lake Ontario ice lobe, they probably came from New York state, where the typical Pulaski strata are exposed.

Hall found this species in situ at Washingtonville, Oswego county, which was the type locality also for *Cyrtolites ornatus*.

If the name *Catazyga erratica* is to be limited to those specimens which show a distinct flattening of the median part of the pedicle valve, then few specimens are known from the Lorraine of Canada. Some typical specimens were collected by E. J. Whittaker from near Toronto.

Specimens collected by the writer from near Weston, in the *Pholadomorpha* zone, have a distinctly narrower elevation along median line of pedicle valve, with only a slight flattening along top of this valve or with no flattening whatever. Similar specimens occur at the 167 and 203-foot levels, above the lake, on Workman brook, in the *Pholadomorpha* zone, and at the 325-foot level, in the Waynesville.

The earliest known appearance of *Catazyga* appears to be the species *Catazyga uphami* Winchell and Schuchert, described from the Prosser member of the Trenton, in Minnesota. Apparently *Catazyga* is a North Atlantic genus, its nearest relative in European waters being *Glassia*.

Cuneamya neglecta (Meek)
Plate XVII, Figure 2

Grammysia neglecta Hall and Whitfield, Geol. Surv., Ohio, Pal. 2, 1875, p. 91, pl. 2, fig. 11.

Shell obliquely ovate longitudinally, the lower posterior angle rounding more rapidly than any other part of its outline. Beaks large and ventricose, arching upward and forward so as to produce a nearly vertical outline along the anterior face of the shell. Posterior to the beak the cardinal and ventral margins approach each other at a moderate rate. Posterior end of hinge-line merging gradually into upper posterior outline, forming an angle of about 50 degrees with the latter.

Locality and Horizon. Originally described from the Waynesville, southwestern Ohio.

A specimen with somewhat similar outline, but no doubt belonging to a different species, was found in the *Proetus* zone of the Lorraine about 2 miles northwest of Vars.

Cuneamya scapha Hall and Whitfield
Plate XVII, Figure 3

Cuneamya scapha Hall and Whitfield, Geol. Surv., Ohio, Pal. 2, 1875, p. 92, pl. 2, fig. 12.

Shell elliptical oblong in outline. Ventral margin straight or slightly concave for greater part of its length, and nearly parallel to hinge-line. Upper anterior margin, along the lunule, slopes downward and forward from the beak at an angle of 60 to 70 degrees, curving abruptly and angularly into lower anterior margin. Beaks rather narrow, owing to angularity of umbonal ridge toward beak. Immediately below the beaks shell is ventricose. Between this ventricose part and the umbonal ridge the valves are flattened or gently concave, there being a broad but very shallow mesial sinus.

Locality and Horizon. Originally described from Waynesville of Waynesville, Ohio.

A specimen similar in outline, but no doubt belonging to a different species, occurs in the *Proetus* zone of the Lorraine, in the Nicolet River section.

Cuneamya scapha brevior Foerste
Plate XXX, Figure 12

Cuneamya scapha brevior Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 307, pl. 2, fig. 12.

Shell closely related to *Cuneamya scapha* Hall and Whitfield, but relatively shorter, and hence with a less inclined umbonal ridge and mesial sulcus. Angle between umbonal ridge and hinge-line approximately 48 degrees, median part of mesial sulcus forming an angle of about 70 degrees. Mesial sulcus about 15 mm. wide near the basal margin, and distinct even close to the beak, although this may be only an individual characteristic. Beak broader and far less acute than in the figure of the type in volume II of "Palæontology of Ohio." Anterior outline, however, closely similar. Umbonal ridge rounded, not angular, and posterior margin more evenly rounded posteriorly. Concentric striæ or low, narrow undulations, fairly distinct anteriorly, becoming fainter along the umbonal ridge and on cardinal slope.

Length 32 mm.; height at posterior end 18 mm.; height at beak 20 mm.; extension of shell anterior to beak about 3 or 4 mm.; length of lunule about 7 or 8 mm.

From below the 8-foot level at the Don brick-yard, Toronto, Miss Stewart figures a form similar in outline to *C. scapha brevior*, but the beak extends almost as far forward as anterior margin of shell; instead of being traversed by a mesial sulcus, preumbonal part of shell fairly evenly convex; and ventral margin also broadly convex, instead of straightened or slightly concave. The specimen apparently represents a distinct form.[1]

Locality and Horizon. Huron river, near St. Jean Baptiste, collected by Thomas Curry (No. 8407). From the *Pholadomorpha* zone or from the lower part of the Richmond formation. At the same horizon, half a mile south of St. Hilaire.

Similar specimens occur in the *Proetus* zone northwest of Vars and in the Nicolet River section. Also in the *Cryptolithus* zone at St. Hugues and St. Hyacinthe. Probably distinct species.

Cuneamya elliptica Miller
Plate XVII, Figure 1

Cuneamya elliptica Miller, Jour. Cincinnati Soc. Nat. Hist., 4, 1881, p. 317, pl. 8, figs. 3, 3*a*.

Shell longitudinally elliptical in outline, excepting at the beak which projects diagonally upward and forward like other species of the genus. Anterior margin projects in front of the beak sufficiently to produce a concave outline along the lunule, sloping downward and forward at about 65 degrees with the hinge-line. Shell ventricose along the umbonal ridge. The ridge becomes broadly rounded posteriorly, merging into the general convexity of the shell. A faint mesial sulcus extends downward and backward from beak at 75 degrees with hinge-line.

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[1] "Stratigraphy and Paleontology of Toronto and Vicinity," 1920, pl. 1, fig. 1.

Locality and Horizon. Described originally from McMillan member of the Maysville, Cincinnati, Ohio.

A specimen somewhat similar in outline was found in the Pulaski member of the Lorraine formation, at Pulaski, New York.

Ctenodonta iphigenia Billings
Plate XVI, Figure 2 *a, b*

Ctenodonta iphigenia Billings, Pal. Foss., 1, Geol. Surv., Can., 1865, p. 152, fig. 132.

Valves diagonally subrhomboidal, broadly rounded antero-ventrally, prolonged at lower posterior angle. Upper outline anterior to beaks, and the ventral outline, are nearly parallel, the distance between these two outlines equalling about half the greatest length of shell. Posterior outline comparatively straight or slightly concave, and forming an angle of about 135 degrees with that part of its upper outline which is anterior to the beak. Lower posterior outline narrowly rounded. According to Billings: "There is a somewhat sharply angular umbonial ridge running from the beaks to the posterior extremity. * * * It resembles *C. nasuta,* but differs from that species by having a strong posterior umbonial ridge."

Interiors of Valves. Interiors of three right valves are at hand. One of these is 25 mm. long, and 15·5 mm. high at the beak. Upper posterior margin forms an angle of 50 degrees with the ventral outline. Shell evidently strongly convex along umbonal ridge, but the degree of angularity of the latter cannot be determined definitely in this view of the interior of the valve. Teeth along the hinge comparatively coarse. Anterior to the beak seven of the more prominent teeth occupy a length of 5 mm., but the total number here may have equalled ten or eleven. Anteriorly the hinge-area has a length of 10 mm. from the angle directly beneath the beak, and posteriorly it is 8 mm., but the total number of teeth cannot be determined here (No. 8479). Another specimen, 18·5 mm. long, 11·5 mm. high, has a hinge-area 6 mm. in length anterior to the beak, with seven teeth in a length of 4 mm., but the total number of teeth here not determinable (No. 8480). From the gully north of Manitowaning, in the Kagawong member.

Locality and Horizon. Originally described as from cape Smith. It is assumed that the type of *C. iphigenia* came from the Clay Cliffs locality. Most of the fossils found here belong to the Meaford member, but all *C. iphigenia* actually found in place came from the Kagawong member. A loose specimen, collected at Clay cliffs, is number 8481. Unfortunately the type of the species has been lost. Two miles northwest of Gore Bay, from the Kagawong member.

Specimens were also seen 8 miles south of Kagawong, and near Wekwemikongsing, all from the Kagawong member. Found on northeast shore of Drummond island, in strata equivalent to Whitewater member of Richmond.

Ctenodonta filistriata Ulrich
Plate XVII, Figure 7 *a, b*

Ctenodonta filistriata Ulrich, Geol. Minnesota, 3, pt. 2, 1894, p. 599, figs. 44 *a-e.*

Outline subrhomboidal ovate. Maximum curvature of the ventral outline directly beneath the beaks, posterior to this the ventral outline tends to straighten slightly and to rise at an angle of 13 to 15 degrees. Umbonal ridge fairly distinct, and outline of the shell along the lower posterior angle rather narrowly rounded. Posterior margin only gently rounded and forming an angle of 50 to 65 degrees with the hinge-line. On casts of the interior of the valves, the beaks are relatively prominent and narrow.

Locality and Horizon. From the Eden formation in the vicinity of Cincinnati, Ohio.

Specimens similar in outline occur in the *Proetus* zone at Chambly Canton, and in the Nicolet River section.

Under the term *Ctenodonta filistriata* Miss Stewart figures from the 25-foot level at the Humber River cut, Toronto, a form belonging to the *C. recurva* section of the genus (*Palæoconcha* of Miller). It appears to differ from any described species in the moderate prominence of the beak and the relatively great width of its lower part.[1]

Ctenodonta albertina Ulrich
Plate XVII, Figure 5 *a, b*; Plate XVI, Figure 7 *a, b, c*

Ctenodonta albertina Ulrich, Geol. Minnesota, 3, pt. 2, 1894, p. 598, pl. 42, figs. 76-82.

Specimens triangularly ovate in outline, posterior part of the ventral margin tending to rise at an angle of 25 or 30 degrees above the horizontal, causing the posterior end of the shell to be of small height. Lower posterior angle narrowly rounded, and the posterior margin forming an angle of about 125 degrees with the hinge-line. Anteriorly margin of shell broadly rounded, forming angle of about 82 degrees with the hinge-line. Anterior part of the ventral outline broadly rounded, maximum height of shell being directly under the beaks, anterior to which the shell extends only a short distance. Surface smooth. Posterior muscle impressions conspicuous.

Locality and Horizon. From Waynesville member, Ohio.

Snake Island Specimens. Specimens similar to *C. albertina* common in the loose blocks of limestone of Snake island, evidently from a lower horizon than anything exposed on that island. They are regarded as coming from the Waynesville (No. 8470).

[1] Stratigraphy and Paleontology of Toronto and Vicinity, 1920, pl. 1, fig. 5.

Ctenodonta simulatrix Ulrich

Plate XVII, Figure 8 *a*, *b*

Ctenodonta simulatrix Ulrich, Geol. Minnesota, 3, pt. 2, 1894, p. 600, pl. 42, figs. 74, 75.

Valves longitudinally ovate elliptical, broadly and evenly rounded anteriorly, more rapidly rounded posteriorly, intermediate ventral outline being broadly and evenly convex with its lowest point at mid-length. Both anterior and posterior parts of hinge-line slope obliquely downward. Teeth relatively small and numerous. On casts of interior of the valves, the umbonal part narrow and correspondingly prominent. Anterior and posterior muscle impressions not conspicuous.

Locality and Horizon. From the Maquoketa member, Minnesota.

Ctenodonta madisonensis Ulrich

Plate XVII, Figure 6 *a*, *b*; Plate XVI, Figures 4 *a*, *b*; 3 *a*, *b*

Ctenodonta madisonensis Ulrich, Geol. Minnesota, 3, pt. 2, 1894, p. 597, pl. 42, figs. 65, 66.

Shells rotund ovate, anterior margin broadly rounded, extending only a short distance anterior to the beak, and rounding with very little angularity into the hinge-line. Lower posterior angle also broadly rounded, and posterior margin forms an angle of about 130 degrees with the hinge-line. Ratio of height to length about 4 to 5. No trace of Arnheim fauna is known in Canada.

Locality and Horizon. From Arnheim member, Madison, Indiana.

Wekwemikongsing specimens differ from *C. madisonensis*, at Madison, in the steeper slope of the post-umbonal region, and in the shorter hinge-line. Hinge-area wide, and teeth large and few, mostly strongly geniculate. Surface of the shell smooth. At and south of Clay cliffs and nearly 3 miles north of Wekwemikongsing, in the Sheguiandah (Nos. 8482, 8483).

Ctenodonta myalta Stewart

Plate XXII, Figures 4, 5

Ctenodonta myalta Stewart, 29th Ann. Rept. Ontario Dept. Mines, pt. 6, 1920, p. 10, pl. i, figs. 7, 11.

Right valve 6·5 mm. in length, 5·2 mm. in height, with beak 2·7 mm. from anterior margin. Basal outline gently curved, rounding gradually into broadly rounded anterior outline; posteriorly, basal outline rises gradually toward the angle at the posterior end of the umbonal ridge, 2·5 mm. above the level of the base. Umbonal ridge starts off at an angle of 33 degrees with an horizontal line and then curves moderately backward to the posterior angle of the valve. Post-umbonal slope moderately concave, cardinal outline and upper posterior margin forming an angle of about 165 degrees. Valve only moderately convex, convexity equalling about 0·8 mm. Beak small, acute, and closely appressed. General appearance of valve is that of a short *Lyrodesma*.[1]

[1] No. 1025, Royal Ontario Museum of Paleontology; original of fig. 7, pl. 1.

Right valve 3·8 mm. long, 2·6 mm. high, with beak 1·2 mm. from anterior margin; convexity about 0·4 mm. General outline very similar to that of preceding valve, but there is evidence of a short hinge-line, 1·5 mm. in length, visible both anterior and posterior to umbonal part of valve, which rises about 0·4 mm. above the hinge-line. Between the umbonal part and the anterior margin the valve is narrowly concave, as in species of *Ctenodonta*, and the posterior margin of the umbonal ridge is less angular than in the preceding valve.[1]

Locality and Horizon. No. 1025, Royal Ontario Museum, from the 15-foot level at the Humbervale quarry; No. 1026, Royal Ontario Museum, below the 8-foot level at the Don brick-yard; both near Toronto, Ontario, in the Eden.

Ctenodonta chambliensis sp. nov.

Plate XVI, Figure 5 *a*, *b*

Outline very similar to that of *Ctenodonta simulatrix*, Ulrich, from the Maquoketa member of the Richmond in Minnesota, but on casts of the interior umbonal parts more broadly rounded, and less elevated; there are fewer teeth along the posterior part of the hinge-line. Ratio of height to length from 70 to 75 per cent. Surface of the shell almost smooth.

Locality and Horizon. Richelieu river at Chambly Canton, west of the dam, in *Proetus* zone of the Lorraine (No. 8471). Also, in upper part of *Proetus* zone, in the Nicolet River section (No. 8472).

In *C. fecunda* (Hall), from the Maquoketa of Iowa, the ventral margin tends to be angulate medially. In *C. filistriata* Ulrich, from the Eden, Cincinnati, Ohio, and vicinity, shell is more quadratic in outline, both anterior and posterior parts rising higher at the hinge-line, and ventral margin rising distinctly toward its posterior end, throwing its maximum curvature farther to the front, and, finally, the posterior margin meets hinge-line in a more angulate manner, the combined result of these differences being to produce an outline different from *C. chambliensis*.

Ctenodonta hyacinthensis sp. nov.

Plate XVI, Figure 6

Valve sub-rotund; ratio of height to length 5 to 7. Outline almost evenly convex from a short distance in front of the beak, along the anterior and ventral margins, as far as the lower posterior angle. Centre of curvature of this part of the outline lies one-fourth of the height of shell below the hinge-line at mid-length of valve. Along upper anterior and lower posterior borders outline more strongly curved, upper posterior border almost straight, the latter forming an angle of 135 degrees with the hinge-line. Beaks low, and rising only slightly above hinge-line. Hinge-line short, equalling about one-third length of valve. Hinge-area very low, considering the size of the shell, teeth small and inconspicuous.

Compared with *C. filistriata* Ulrich, from the Eden, Cincinnati, the valve is taller, that part posterior to beak is shorter, posterior part of ventral outline curves more strongly upward, the beak is more inconspicuous, and upper anterior outline more strongly convex.

[1] No. 1026, Royal Ontario Museum of Paleontology; original of fig. 11, pl. 1, accompanying the original description; selected in the present publication as the type of the species.

Compared with *C. madisonensis* Ulrich, from Arnheim of Madison, Indiana, the shell is more prolonged anterior to beak, which does not rise as strongly above hinge-line.

Locality and Horizon. Richelieu river, St. Hyacinthe, below the dam, in *Cryptolithus* zone of the Lorraine. Collected by Robert Harvie (No. 8586).

Ctenodonta pectunculoides (Hall)

Plate XVII, Figure 9

Tellinomya pectunculoides Hall; Hall and Whitfield, Geol. Surv. Ohio, Pal. 2, 1875, p. 81, pl. 1, fig. 24.

Outline nearly circular, slightly straightened along the hinge-line, posterior to the beak. Height slightly shorter than length, in ratio of 9 to 10. Hinge-area of uniform width along its entire course, with about thirty short teeth. Size small.

Locality and Horizon. From Eden and Maysville, Cincinnati vicinity. Similar specimens occur in the Lorraine, *Pholadomorpha* zone at St. Hilaire and south of Clay cliffs.

Ctenodonta lorrainensis Foerste

Plate XXXI, Figure 8; Plate XXXVIII, Figure 3

Ctenodonta lorrainensis Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 305, pl. 3, fig. 8 A (not 8 B).

Shell small, rotund in outline, length and width about 9 mm., with a slight tendency toward angulation at the posterior extremity, owing to a straightening of the posterior part of the arcuate hinge-line, as in *C. pectunculoides* Hall, from the Mount Hope and Fairmount beds of the Maysville, Cincinnati, Ohio. In the latter species, however, the tendency is toward a greater length than height of the valves, whereas *C. lorrainensis* tends toward a slightly greater height than width. This results in a less angulate posterior outline. Also, the height of the hinge-area, compared with the rest of the shell, is less. Surface with very fine concentric striæ, seen readily only under a lens.

Locality and Horizon. Originally described from the Pulaski near Worthville, New York.

Similar specimens occur in the *Proetus* zone at Chambly (No. 2083), and northwest of Hawthorne. In the Nicolet River section, they make their appearance in the *Proetus* zone and range upward into the *Pholadomorpha* zone in which they occur also south of St. Hilaire.

Ctenodonta borealis sp. nov.

Plate XXXI, Figure 9; Plate XXXVIII, Figure 4

Ctenodonta lorrainensis (pars) Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 305, pl. 3, fig. 8 B (not 8 A).

This specimen is of the same size as the type of *C. lorrainensis*, but broader, more circular, the hinge is much broader, and teeth distinctly fewer.

Locality and Horizon. From the Lorraine near Worthville, New York, associated with, but apparently distinct from, *C. lorrainensis*.

Ctenodonta cingulata Ulrich
Plate XVII, Figure 10

Ctenodonta cingulata Ulrich, Geol. Surv., Ohio, 7, 1893, p. 680, pl. 48, figs. 10-12.

Outline nearly circular, slightly interrupted at the beak, height about the same as length. Hinge-area broad, especially beneath the beak. Teeth about forty, progressively taller toward the beak, beneath which they are narrow and closely crowded laterally. Diameter 20 mm.

Locality and Horizon. From the Waynesville, Marble Hill, Indiana. Identified also from Kentucky.

Specimens belonging to the same group, but not known to be identical, occur in the Meaford 7 miles northwest of Meaford, and in the Lorraine-like strata in the lower part of the Waynesville member at Streetsville.

Ctenodonta cingulata gorensis var. nov.
Plate XVI, Figure 1

Outline almost circular, length almost equalling width; upper anterior margin less convex, resulting in a slightly more angular outline at the beak and at mid-height along the anterior margin. Compared with C. *cingulata*, the shell is slightly broader, hinge-area much narrower, and only a few of the teeth near beak closely crowded and subparallel. Teeth about thirty-five in number, short and geniculate except immediately beneath the beak. Length 12 mm., height 13·2 mm.

Locality and Horizon. Two miles northwest of Gore Bay, at the top of the hill in the Kagawong member (No. 8484).

Clidophorus planulatus (Conrad)
Plate XVII, Figure 12; Plate XXIX, Figure 13

Clidophorus planulatus Hall, Pal. New York, 1, 1847, p. 300, pl. 82, figs. 9 *a-d.*

Shell gently convex, elliptically ovate lengthwise, broadest anteriorly beneath beaks, narrowing posteriorly, ventral margin rising at moderate rate as far as the lower posterior angle, which is very narrowly rounded. Upper posterior margin obliquely and angularly truncated. Clavicular ridge inclining obliquely downward and forward from the beak at about 20 degrees with the vertical, in some cases more.

Locality and Horizon. Originally described from Pulaski member, Pulaski, New York.

In field notes it has been listed from *Cryptolithus* zone of the Lorraine at St. Hugues and St. Hyacinthe; from the *Proetus* zone in the Nicolet River section; and in the *Pholadomorpha* zone at Weston and three-quarters of a mile south of Clay cliffs. It is not certain that all these identifications are correct.

From the 3-foot level at the Don brick-yard, Miss Stewart figures a *Clidophorus* which differs from *C. planulatus* conspicuously in its outline, broadening posteriorly from a narrowly rounded anterior extremity.

Upper margin anterior to the beak nearly at the same level as that part which is posterior. Umbonal ridge more strongly defined and clavicular ridge inclining forward at about the same angle as in *C. planulatus*.[1]

Clidophorus tamarackensis sp. nov.
Plate XLIII, Figure 8

Right valve 11·5 mm. long, 6·3 mm. high, with beak 3 mm. from the anterior end; convexity 1·2 mm. The clavicular ridge starts off 0·6 mm. anterior to the highest part of the beak; it descends vertically for half its length and then curves forward, maximum forward slant at its base scarcely equalling an angle of 20 degrees with the vertical. Total length of clavicular ridge 1·7 mm., its base terminating about 0·7 mm. above mid-height of the valve. Width of the ridge barely ⅛ mm.

General appearance of this valve similar to that of some of *C. planlatus*. Distinguished chiefly by narrowness of clavicular ridge and its nearly vertical direction; also, the beak is slightly nearer the anterior margin of the shell.

Locality and Horizon. From the Sheguiandah shale north of Tamarack point.

Clidophorus prævolutus Foerste
Plate XXIX, Figures 6 *a, b;* 12

Clidophorus prævolutus Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 303, pl. 1, figs. 12, 6.

Longitudinally elliptical; length 11·5 mm.; height 5·2 mm.; ends narrowly rounded. Anteriorly the shell extends 3·5 mm. in front of the beak; here the cardinal outline is comparatively straight and forms an angle of about 165 degrees with the hinge-line back of the beak. Posteriorly there is a narrow concave subalate cardinal slope, barely a millimetre wide at its posterior end; along this part of the shell the hinge-line is straight for about 5 to 6 mm. and then joins the upper part of the posterior margin at an angle of about 120 degrees. Surface marked by fine concentric lines, not readily seen except under a lens. A cast of the interior shows a narrow, slightly sigmoid, clavicular adductor support impression just in front of the beak, forming an angle of 65 degrees with longitudinal axis of shell, and extending about 2·5 mm. from the tip of the beak. Anterior to this clavicular support groove a broad, shallow depression extends across the shell from the beak to the anterior part of the basal margin at about 55 degrees with the longitudinal axis. Anteriorly, this shallow depression is bounded by a low, transverse ridge or fold, also extending from the beak toward the anterior part of the basal margin, at an angle varying from about 45 degrees near beak to 50 degrees near basal margin. It is the shallow depression and low fold anterior to the clavicular support impression which is regarded as most typical.

Miss Stewart figures from the Don brick-yard a species similar to *C. prævolutus* in having an oblique fold anterior to the beak, but differing in almost every other respect. The oblique fold is narrower and on the casts of the interior much more sharply defined posteriorly, by a narrow

[1] "Stratigraphy and Paleontology of Toronto and Vicinity," 1920, pl. 1, fig. 12.

groove at its lower end about ⅔ mm. in front of the groove left by the clavicular ridge. Ridge almost vertical. Height of shell greater, its outline oblong, with dorsal and ventral sides subparallel, and anterior and posterior ends rather broadly rounded.[1]

Locality and Horizon. Richelieu river, near Chambly, collected by A. H. Foord. Associated in the same specimen with *Glossograptus quadrimucronatus approximatus* and *Rafinesquina alternata*. From the *Proetus* zone (No. 2079). Also near Vars.

Similar specimens occur in the *Pholadomorpha* horizon at St. Hilaire, and in the Nicolet River section; also in the lower Richmond at Huron river, but the specimens from these higher horizons require more detailed study before being specifically identified with *C. prævolutus*.

Clidophorus postvolutus sp. nov.

Plate XVI, Figure 8 *a*, *b*

Shell elliptical in outline, ventral margin broadly convex, anterior and lower posterior margins narrowly rounded, especially the lower posterior margin where the posterior outline curves forward until it forms an angle of 30 to 35 degrees with the hinge-line. Length 16 mm.; width 8·5 mm.; convexity of single valve slightly over 3 mm. Clavicular groove in the cast of the interior of the specimens almost vertical, forming an angle of 95 degrees with the hinge-line. The most characteristic feature is the prominence of the umbonal ridge posteriorly. This ridge terminates, as in other species, at the lower posterior angle, but is defined along its posterior half by a very shallow depression which begins about 4 or 5 mm. from the beak and broadens out posteriorly. Course of this groove sufficiently diagonal to the length of the umbonal ridge to form an angle of about 15 degrees with the latter. Very faint concentric striæ present. On one specimen equally faint radiating striæ are seen along the umbonal slopes, but these striæ do not seem to be a constant feature.

Triarthrus occurs at an horizon 350 feet higher than that at which the types of *Clidophorus postvolutus* were found. Fifty feet below this *Triarthrus* zone, *Cymatonota* was found. So far, *Cymatonota* has not been cited below the level of the Eden.

Locality and Horizon. Nicolet River section, in the *Cryptolithus* zone of the Lorraine, 2,000 feet below horizon at which *Rhynchotrema perlammelosum* and *Strophomena planumbona* occur in the lower part of the Waynesville. Here it is associated with *Glossograptus* (*Orthograptus*) *quadrimucronatus* (No. 8476).

Yamaska River Specimens. Smaller, attaining a length of 10 mm., but having the same general outline and convexity as typical *C. postvolutus*. Although there is no indication of the broad, shallow depression on the lower side of the umbonal ridge posteriorly in the smaller specimens, in the larger ones such a depression is indicated faintly. Clavicle in undistorted specimens nearly vertical, but many specimens are somewhat distorted, so that the clavicle appears more or less backward or forward. Yamaska river, 1·5 miles northwest of St. Hugues. Associated with *Cryptolithus*, *Triarthrus*, and *Leptæna*, in the *Cryptolithus* zone of the Lorraine (No. 8477).

[1] "Stratigraphy and Paleontology of Toronto and Vicinity," 1920, pl. 1, fig. 10.

Clidophorus obliquus Stewart

Plate XXII, Figure 6

Clidophorus obliquus Stewart, 29th Ann. Rept. Ontario Dept. Mines, pt. 6, 1920, p. 12, pl. 1, fig. 9.

Right valve 13 mm. in length; its basal margin curved under, owing to pressure, so that its height is reduced, from about 6 mm. Beak 5·5 mm. from anterior margin. Cardinal outline not preserved and must be inferred from convexity of valve and the course of the concentric striæ. Convexity of valve about 1·2 mm. Umbonal ridge rounds gradually into postumbonal slope. Groove locating the clavicular ridge on interior of the valve starts off about 0·7 mm. anterior to the beak, at an angle of 80 degrees with length of valve, and curves forward until angle becomes 65 degrees and finally 45 degrees. In Plate XXII, figure 6, the anterior and posterior outlines are based on the course of the concentric striæ. These are very fine and distinct only within 2 mm. of the margin. The long, anterior extension of the valve and the strong forward curvature of the clavicular ridge are distinguishing features.

Locality and Horizon. From 17-foot level at Humber River cut, near Toronto (No. 1018 H.R., Royal Ontario Museum of Paleontology). Type specimen, from the lower part of Lorraine.

Clidophorus neglectus Hall

Plate XVII, Figure 11 *a-f*

Clidophorus neglectus Ulrich, Geol. Minnesota, 3, pt. 2, 1894, p. 607, pl. 42, figs. 20-25.

Shells longitudinally subelliptical, end rounded subequally, upper side of posterior end very obliquely subtruncated. Height about one-half of length. Beaks about one-third of length of the shell from the anterior end. Valves rather strongly convex. Clavicular ridge nearly vertical.

Locality and Horizon. Originally described from the Maquoketa of Wisconsin. Listed also from Minnesota, Iowa, Illinois, and Missouri.

A form similar in outline occurs in the *Cryptolithus* horizon of the Lorraine, at St. Hugues, but probably belongs to a different species.

Clidophorus brevis sp. nov.

Plate XVI, Figure 9 *a, b*

Specimens relatively short and tall, ratio of height to length about 7 to 10. Anterior and lower posterior margins more broadly rounded than in most species of *Clidophorus*. Posterior margin forms an angle of 50 to 60 degrees with the hinge-line. Umbonal ridge broadly rounded, except toward the beak. In casts of the interior, groove left by clavicular ridge very sharp and narrow; slightly concave toward front, and sloping slightly forward, forming an angle of 12 to 20 degrees with the vertical. Most specimens about 9 mm. in length.

Locality and Horizon. St. Hyacinthe. From the *Cryptolithus* zone in the Lorraine. Collected by Robert Harvie (No. 8586).

Cyrtodonta ponderosa Billings

Plate XVIII, Figure 1 *a, b, c*; Figure 2 *a, b, c*; Plate XXXVIII, Figure 1 *a, b*

Cyrtodonta ponderosa Billings, Pal. Foss., 1, Geol. Surv., Can., 1865, p. 150.

Hinge short, compared with maximum length of shell, along umbonal ridge. In a specimen having a maximum length of 72 mm., length of the hinge only 32 mm. Beak close to anterior end of hinge-area; the umbonal ridge very oblique to the base of the longitudinally striated part of this area. In different specimens this angle varies from 60 to 65 degrees, producing angles as low as 40 degrees with the upper part of striated area. Posterior outline of the shell starts off from the upper margin of the striated area at an angle of about 30 degrees and curves gradually downward as far as posterior end of umbonal ridge. Here it curves strongly forward into the moderately convex basal outline. Along the anterior margin, the outline curves more strongly upward, but the anterior part of the shell extends only slightly beyond the anterior end of the hinge-area. This very oblique and elongate outline of the shell, and the relative shortness of hinge-area, especially anterior to the beak, are the characteristic features of this species.

The type specimen (No. 2081) is a large representative of the species, but the antero-ventral margins are somewhat worn away and the specimen has been crushed obliquely so as to depress the left beak below the level of that belonging to the right valve. On this account, a second specimen (No. 8552), found by M. Y. Williams at the type locality, Clay cliffs, has been chosen for purposes of measurement, though only about 0·82 as long.

In this specimen, angle between umbonal ridge and lower part of hinge-area estimated at 60 to 65 degrees. Length along umbonal ridge, 61 mm. Length of hinge-area 28 to 30 mm. From posterior end of hinge-margin to anterior of the less convex part of ventral margin, the transverse diameter is 40 mm. Thickness from valve to valve, 29 mm. Point of greatest thickness 15 mm. from the beaks. From the concentric markings it is evident that an acceleration of growth took place in a direction parallel to the umbonal ridge, so that older shells appear narrower and more oblique than younger individuals. Striated part of hinge-area high in many large specimens, equalling 6 mm. Lower edge of hinge-plate curving downward anteriorly, below level of striated area, for 8 or 9 mm. in larger sized specimens, and here the cardinal teeth are located. These vary in number, size, and prominence, as a rule three or four stronger teeth, and an equal number of small teeth, directed at angles of about 50 degrees with the basal margin of striated area. Below anterior part of this toothed area, anterior muscle impression is excavated from the obliquely declined, inner surface of the very thick anterior border of the shell. Postero-lateral teeth very long, corresponding to the great elongation of posterior outline of shell. Near striated part of the hinge-area two of these posterior teeth may be detected, but, at a greater distance, only the lower one of these is distinctly defined; the latter may have a length of fully 20 mm. in larger sized valves (No. 8498).

Locality and Horizon. Originally described from the Richmond of the Clay cliffs. Known also from exposures 2 miles southwest of Wekwemikong, at Manitowaning, southwest of Indian village, east of Kagawong lake, 2 miles southeast of Kagawong, 2 miles northeast of, and 1·5 miles northwest of, Gore Bay.

Cyrtodonta ponderosa perobliqua var. nov.
Plate XVIII, Figure 3; Plate XIX, Figure 1 *a, b, c*

It is evident from the concentric surface markings of *Cyrtodonta ponderosa* that, with increasing age, there is an acceleration of growth in a direction parallel to the umbonal ridge, so that older shells appear relatively narrower and more oblique. At some horizons, in the Kagawong, this type of outline is seen even in the younger shells, the elongation becoming accentuated with age, so that in mature specimens width of shell, in a direction transverse to that of the umbonal ridge, equals only about 50 to 55 per cent of its maximum length. Angle between umbonal ridge and hinge-area 60 to 65 degrees, as in typical *C. ponderosa*, but, owing to the narrowness of the valves, general appearance of shell more oblique. Narrowness due chiefly to diminished growth along antero-ventral parts of shell. For specimens of this type the varietal name *perobliqua* is proposed.

Locality and Horizon. Very common in the silicified limestone, 2 miles southwest of Kagawong, on the road to Gore Bay (No. 8498).

Cyrtodonta ovalis sp. nov.
Plate XIX, Figure 2

Valves ovate-triangular in outline. Umbonal ridge forming an angle of about 65 degrees with the longitudinal striæ on ligamental part of hinge-area, as in *C. ponderosa*, but elongation of shell along this umbonal ridge less; hinge-area more prolonged posteriorly; posterior outline of valves, though broadly rounded, more erect; ventral outline moderately curved; anterior outline more strongly curved, and point of maximum curvature nearer the hinge-line. The result is a subtriangular outline in which the upper posterior angle, though broadly rounded, extends farther back than in any known specimens of *C. ponderosa*. Shell relatively thin.

Compared with the latter species, the interior of the shell presents even greater differences. Hinge-area lower in height, cardinal teeth much less conspicuous, anterior part of shell far less thickened, and does not provide a thick platform for support of anterior muscle impression. Longitudinally striated ligamental part of hinge-area, 28 mm. long, and 2·5 mm. high. Anterior edge of this area extends about 5 mm. in front of the beak. Cardinal teeth, 4; all short, and erect. The upper end of third tooth appears to extend forward horizontally over the tops of the two anterior teeth, and the top of the fourth tooth curves slightly forward. The wide posterior border of the shell bears three long ridges or posterior lateral teeth.

Locality and Horizon. Four miles southwest of Little Current, nearly a mile southwest of Indian village, at the top of a hill on a north-south road. Exact horizon 45 feet above top of main *Stromatocerium* reef at this locality (No. 8499). Shells with a similar outline occur 2 miles southwest of Kagawong, on road to Gore Bay, but expose only their exteriors. From Kagawong member of the Richmond.

Cyrtodonta exigua sp. nov.
Plate XIX, Figure 3 *a, b, c, d*

Beaks small, closely appressed; umbones not prominent, rounding into the general convexity of shell anteriorly, only moderately more prominent posteriorly than umbonal ridge. Longitudinally striated ligamental part of hinge-area low. Cardinal teeth 3; all stronger at their inner ends, and tending to curve forward in an horizontal direction, the two posterior teeth overlapping in succession the tooth immediately in front; the third tooth the weakest of the group. Shell relatively thin, leaving anterior border strongly inclined, and on this border rests the anterior muscle scar.

Shell relatively small in height, compared with length; upper anterior outline narrowly convex, greatest curvature close to hinge-line. Anterior part of shell extending considerably in front of beaks; posterior part of shell prolonged along hinge-line. Umbonal ridge low and inconspicuous so that general form of shell is longitudinally oblong rather than strongly oblique.

Locality and Horizon. Two miles northwest of Gore Bay, at the top of the hill along an east and west road (No. 8453).

Cyrtodonta kagawongensis sp. nov.
Plate XIX, Figure 4

An interior of a left valve associated with the interiors of the right valves of *Cyrtodonta stewarti* agrees with the latter in its almost straight and strongly oblique antero-basal outline and its relatively high posterior end, but the strong anterior curvature of outline appears higher up. Anterior teeth more nearly parallel to striated part of hinge-area. No depression corresponding to the strong oblique tooth beneath beak in right valve of *C. stewarti*, posterior ends of posterior teeth curve distinctly downward, and anterior muscle scar is more shallow and less distinctly defined posteriorly. General appearance of dentition of this shell much more strongly Cyrtodontoid than in the case of *C. stewarti*.

Locality and Horizon. Two miles southwest of Kagawong, in the Kagawong member.

Vanuxemia (?) *bayfieldi* Billings
Plate XX, Figure 1

Vanuxemia bayfieldi Billings, Geol. Surv., Can., Rept. of Prog., 1857, p. 187, fig. 17.

"Very ventricose, ovate; anterior extremity, including the beaks, narrowly rounded. Shell very thick. Seven anterior teeth. Anterior muscular impression large, deep, and excavated in the very much thickened edge of the shell. Posterior impression subcircular, superficial, situated just beneath posterior extremity of hinge-line. Bayfield sound. Only interior seen. Exterior covered by *Mont. petropolitana.* Hudson River group." (Original description by Billings.)

Exterior surface of type specimen embedded in rock, and only its interior exposed. Specimen imperfect. Basal and posterior parts, and even anterior margin, missing and original outline largely conjectural. Thickness of shell along the broken margin, in the region of the umbonal ridge about 1·5 mm., and this suggests considerable posterior extension of the original complete shell beyond its present broken margin, possibly producing an obliquely elongate, rather than rotund, outline. Horizontally striated ligamental area, along upper part of hinge-area not outlined clearly, although original cleaner of fossil left a depression in the general location of this ligamental area. Seven cardinal teeth clearly defined. Of these, the one nearest the lower margin of the ligamental area makes an angle of about 15 degrees with the latter, and the most distant tooth of the seven makes an angle of about 35 degrees. In addition to these seven cardinal teeth, the cleaner has left an indication of an eighth tooth immediately beneath ligamental area, and, finally, there is a ninth, clearly defined but very short, tooth next to the anterior muscle impression. The upper part of the middle tooth may have arched forward and then curved downward anteriorly, so as partly to include the lower teeth of the series, but, along the anterior terminations of the cardinal teeth, the shell is preserved imperfectly. Parts of two posterior teeth at the opposite end of the hinge are defined clearly for short distances, and the cleaner has left indications of at least one additional posterior tooth. These make an angle of about 40 degrees with lower margin of ligamental area.

Anterior muscle impression rests upon the very much thickened anterior margin of the shell, very much as in *C. ponderosa* Billings. Posterior muscle impression very indistinctly indicated.

Type specimen a left valve, which evidently was very thick. Anteriorly this thickness must have equalled at least 3 mm., possibly 4 mm.

No other specimen of *Vanuxemia* which can be identified with the type of *V. bayfieldi* has been found on Manitoulin island. In fact, until better specimens have been discovered, the generic reference of this Bayfield Sound specimen to *Vanuxemia* cannot be regarded as established satisfactorily.

If the type of *V. bayfieldi* be oriented in such a manner as to place its cardinal area in same position as that of *Cyrtodonta ponderosa* or *C. perobliqua*, a sufficient resemblance between the dentition of the Bayfield Sound type with the latter is observed to make their generic identity at least not impossible. The chief difference consists in the greater number of cardinal teeth in the former, and in the small inclination of these teeth. Location of anterior muscle impression on the thickened upper anterior border of the shell does not prevent its association with *C. ponderosa,* since some of the individuals of the latter species show very similar features. The chief difference noted so far is that in *Vanuxemia bayfieldi* the inner margin of the muscle impression is more elevated as in true *Vanuxemia,* whereas in *Cyrtodonta ponderosa* this impression inclines more distinctly downward along its inner margin, but even in this respect some of the *C. ponderosa* specimens are very similar to the Bayfield Sound valve.

Locality and Horizon. Bayfield sound. This sound is entirely enclosed by Silurian strata, belonging to the Cataract and overlying formations, excepting along the eastern part of Barrie island, where there is exposed only the Kagawong member, including the *Stromatocerium* reef. The type is regarded as coming from the *C. ponderosa* horizon in upper part of the Richmond (2084).

Vanuxemia kagawongensis sp. nov.
Plate XX, Figure 2 *a, b, c, d*

Outline rotund, somewhat as in *V. abrupta* Ulrich, from the Prosser member of the Trenton in Minnesota, but with the hinge-line shorter and rounding more gradually into posterior outline of shell. Maximum length, measured from the beak diagonally, 36 mm. Length of striated part of hinge-area, 20 mm. Anterior part of this striated area extends only 1 mm. in front of the beaks. This striated part served for attachment of external ligament. The anterior face of shell, extending from anterior side of beaks downward for about 15 mm., flattened distinctly. Viewed from the front, the tips of beaks curve forward and inward, terminating close to flattened anterior face of shell.

Height of shell 30 mm.; length, measured parallel to hinge-area, 33 mm.; convexity of single valve, 11 or 12 mm. Striated part of hinge-area 2·5 mm. in height. Cardinal teeth somewhat as in *Vanuxemia subrotunda* Ulrich, from Decorah member of the Black River, Minnesota, arching forward over upper part of anterior muscle impression. Three cardinal teeth, successively larger toward the top; the two upper ones transversely corrugated. Anterior muscle impression relatively large, shallow, flat-bottomed, and obliquely oval in outline; resting upon the very much widened hinge-area.

Locality and Horizon. Kagawong falls, 19 feet above creek level, associated with *Catazyga headi* and *Hebertella insculpta*, but 8·5 feet above the lowest level at which *H. insculpta* is found. From the Meaford member (No. 8500).

Ischyrodonta unionoides (Meek)
Plate XXXI, Figure 15 *a, b*

Ischyrodonta unionoides (Meek), Geol. Surv., Ohio, 7, 1893, p. 677, pl. 54, figs. 1-3.

Shell of medium size, rotund ovate in outline, convexity small. Cardinal margin anterior to beak, but slightly lower than cardinal margin posterior to same. Anterior margin evenly but narrowly rounded; ventral margin rounded, but sloping diagonally downward at an angle of 20 to 30 degrees with posterior hinge-line; lower posterior margin broadly rounded; upper posterior margin curving strongly forward and rounding even more gradually into cardinal margin. Beaks small, projecting very little beyond hinge-line, located between one-fourth and one-fifth of the length of the valves behind the anterior extremity. Umbonal ridge scarcely distinguishable, moderately oblique. Surface with relatively few concentric striæ.

Shell begins as an elliptical form with its longer axis almost parallel to posterior hinge-line. Growth accelerates, however, along diagonal umbonal ridge, at an angle of 35 to 40 degrees with posterior part of hinge-line, and retards in an antero-ventral direction, so that in mature specimens outline becomes triangularly and obliquely ovate, with the chief angle at the upper anterior end of the shell; second angle at posterior end of umbonal ridge; third angle at upper posterior end of its outline.

Miss Stewart figures from the Don brick-yard, Toronto, a species belonging to the *Ischyrodonta unionoides* group, which differs from typical forms of *I. unionoides* in being relatively taller, umbonal region and antero-lateral margin being less oblique.[1]

Locality and Horizon. Described originally from Cincinnati, Ohio, from the Bellevue member. Identified also from the Pulaski formation in New York, and at Grimsby, Ontario.

Ischyrodonta unionoides westonensis var. nov.

Plate XXIII, Figures 11, 12 *a*, *b*

Specimen No. 2088, retaining its elliptical form even when fully mature. Anterior outline more broadly rounded and antero-ventral margin less obliquely inclined.

A second specimen (No. 2074) presents essentially same outline until a length of 33 mm. has been attained. Beyond this length it enlarges still in a direction parallel to umbonal ridge, but very little at right angles to this direction, so that at a later stage of growth the general outline is more oblique, very much as in *I. unionoides*, but with anterior outline more broadly rounded. Greatest length 38 mm.; greatest diameter at right angles to the umbonal ridge, 28 mm.; convexity of the single valve is 8 mm.

The second specimen presents both valves and is remarkable in retaining the thin, black, shiny, chitinous exterior layer of shell. This layer abundantly striated concentrically. The inner layers of the shell also dark, partly replaced by crystalline calcite.

Locality and Horizon. The first specimen described above occurs in crinoidal rock containing traces of *Catazyga* and *Archinacella pulaskiensis*. In general appearance this rock resembles the typical upper Lorraine of New York. The specimen is labelled "Weston, A.M. 64," and on the accompanying label is stated to have come from Weston, Ont.

The second specimen also is labelled as coming from Weston, but lithologically it might have come from Trenton Falls, N.Y. It should be noted, however, that the specimen of *Lyrodesma poststriatum* (Emmons) (No. 2077) also is labelled Weston, and as having been collected by J. B. Tyrrell, although in lithological appearance it looks like a black Trenton Falls specimen. The occurrence of such a black rock in the Weston area requires explanation, and the writer found nothing like it.

Both specimens were presented by Rev. J. M. Goodwillie.

[1] "Stratigraphy and Paleontology of Toronto and Vicinity," 1920, pl. 1, fig. 13.

Ischyrodonta curta Conrad

Cypricardites curta Conrad, 5th Ann. Rept. New York Geol. Surv., 1841, p. 53.
Cypricardites curta Hall, 12th Rept. New York State Cab. Nat. Hist., 1859, p. 9.

Conrad's original description of this species is "Suborbicular, compressed; hinge-margin elevated; posterior margin obtusely rounded. Localities: near Rome, Oneida county, Richmond, Indiana."

Evidently two species are involved in this citation of localities. Formerly the writer assumed that the Rome species was the form at present identified with *I. unionoides*, and that the Richmond species was some form similar to *I. decipiens* Ulrich from the Whitewater member, Richmond, Ind. However, the figure published by Hall[1] evidently is some form of *Cyrtodonta*, so that, in the absence of the types of Conrad's species and of the original of the figure published by Hall, confusion exists. In the absence of any known species of *Cyrtodonta* from the Lorraine the form figured by Hall may be a specimen from Richmond, Ind., where *Cyrtodonta* occurs, and not typical *Cypricardites curta* from Rome, N.Y.

Of the figures presented by Hall under the name *Modiolopsis curta*[2] the Grimsby specimen unquestionably belongs to the Lorraine species at present identified as *I. unionoides*. The Lorraine specimen is a small *Pterinea demissa*. The Mineral Point specimen belongs to a third species, and probably is a *Cyrtodonta*.

Ischyrodonta (?) *manitoulinensis* sp. nov.
Plate XXIII, Figure 10

The specimen consists of a right valve exposing only its interior. Generic relations uncertain. It is referred to *Ischyrodonta* chiefly because it has a single oblique cardinal tooth; the anterior muscle scar comparatively small and distinctly defined posteriorly; and the outline of the shell somewhat resembles that of *miseneri* Ulrich, from the Whitewater member at Richmond, Ind. This resemblance is in the long hinge-line, its anterior part extending a considerable distance in front of the beak. Anterior part of valve narrowly rounded and ventral margin making an angle of about 45 degrees with hinge-line. This results in a triangularly ovate outline. It differs from *I. miseneri* in having ventral outline gently convex. The outline rounds broadly into the dorsal margin, which also is broadly rounded and tends to be erect. Umbonal ridge prominent at umbones, but more steeply inclined, so that shell is shorter. Preumbonal slope flattened and strongly oblique as far as basal margin of shell. Mesial sulcus absent.

Hinge on interior of valve resembles that of *I. unionoides* in its narrowness, in the prominence of a single tooth, and in the presence of a groove along that part of hinge-area which is posterior to beak. This groove apparently was for the reception of a ligament. Unfortunately there is no trace of the pit locating the minute pedal muscle, immediately behind

[1] Twelfth Ann. Rept., New York State Cab. Nat. Hist.
[2] Pal. New York, 1, 1847, p. 297, pl. 81, fig. 4; pl. 82, figs. 2 a–d.

the upper end of the anterior muscle scar, which is a characteristic of the genus *Ischyrodonta*.

Locality and Horizon. Two miles southwest of Kagawong, from the Kagawong member (No. 8495).

Ortonella hainesi (Miller)
Plate XVII, Figure 4 *a, b*

Ortonella hainesi Ulrich, Geol. Surv., Ohio, 7, 1893, p. 670, pl. 53, figs. 9-18.

Outline rhomboid oval, anterior margin inclining at an angle of 120 degrees with hinge-line, ventral margin diverging from hinge-line at an angle of nearly 20 degrees; posterior margin forming an angle of 105 to 115 degrees with hinge-line. Convexity of the valves moderate, beaks being small and closely appressed, and umbonal ridge being of only moderate prominence. A distinct lunule and escutcheon present. Oblique cardinal teeth located directly beneath beak, and long lateral teeth located near posterior end of valves. From beneath the cardinal teeth a long, straight, clavicular ridge extends downward and a little backward, defining the posterior margin of anterior muscle scar. Surface marked by strong concentric striæ.

Locality and Horizon. Originally described from the Whitewater member, Richmond, Ind.

Specimens similar in outline occur at several localities in the Kagawong member, on Manitoulin island. However, since several of these, when their interiors were exposed, turned out to be *Cyrtodontæ*, doubt is cast on all the field notes in which *O. hainesi* is mentioned.

Ortonella (?) *stewarti* sp. nov.
Plate XIX, Figure 5

Shell with anterior outline forming an angle of 60 to 75 degrees with the horizontal line, rapidly rounding at lower anterior end into straight part of basal margin. Posteriorly this basal margin rounds more gradually into the moderately convex posterior margin. No distinct escutcheon along hinge-line.

Interiors of several right valves are at hand, and one of these here is figured and is regarded as the type. Hinge-area striated lengthwise. Beneath the posterior end of the hinge-area are two conspicuous lateral teeth, and one as a rule relatively inconspicuous, all forming a small angle with hinge-area. At anterior end of striated hinge-area is a short tooth directed from beak diagonally downward and backward. Immediately behind this tooth is a depression reaching the lower margin of the unstriated part of the hinge-area; and immediately in front of this tooth is a cavity elongated parallel to the lower margin of this unstriated part. Both of these cavities probably were for the reception of teeth from the left valve. The anterior muscle scar rests on the very oblique inner slope of the lower anterior part of the shell, and is bordered posteriorly by a sharply-defined ridge or border sloping distinctly backward.

Shell marked by a very oblique mesial depression or sinus, which is very weak and which lies only a short distance in front of umbonal ridge.

This depression not infrequently flattened the umbonal part of shell near the beak and gives shell an aspect similar to *Cyrtodonta parva* Ulrich, from the Prosser limestone, Minnesota. Its anterior end, however, projects a much shorter distance in front of beak. The relationship of this species may be with *Ortonella,* but if that be the case both the lunule and escutcheon are much narrower than in the type of that genus.

Locality and Horizon. Two miles southwest of Kagawong, in the Kagawong member (No. 8497*a*). Named in honour of Miss B. H. Stewart.

Ortonella (?) *gorensis* sp. nov.

Plate XIX, Figure 6

Shell subrhomboidal in outline. Ventral margin forms an angle of about 30 degrees with hinge-line. Anteriorly, the shell is narrowly rounded. Between anterior end of shell and beak, the outline is distinctly concave. Ventral margin rounds rather broadly into the posterior margin of the shell. Upper part of the latter tends to be comparatively straight and erect. Beak relatively small and flat. Umbonal ridge low, and not angular. Post-umbonal slope gently concave. Surface of shell strongly striated concentrically. Immediately posterior to the umbonal ridge these striæ curve gently so as to be concave toward the rear, but curve in the opposite direction on reaching the hinge-line.

Compared with *O. hainesi* (Miller) from the Whitewater member, Richmond, Ind. Anterior margin of shell is more narrowly rounded, projects more toward front of beak, and is separated from beak by a more strongly concave upper anterior margin. In the absence of any knowledge of the teeth, generic relations of this species remain in doubt.

Locality and Horizon. Two miles northwest of Gore Bay, at top of hill on an east-west road. In the Kagawong formation (No. 8497 *c*).

Ortonella (?) sp.

Plate XLIII, Figure 4

Shell 21·5 mm. long and 16 mm. high at posterior end; maximum thickness 11·5 mm., including the two valves. Outline very much as in *O. stewarti*, upper anterior margin forming an angle of 60 degrees with the horizontal line. It differs in umbonal ridge being less angular, mesial sulcus more distant from the ridge, and shell is marked by distinct growth lines 3 to 4 mm. apart along umbonal ridge, toward basal end of specimen they are more crowded. There appears to be an escutcheon 1 mm. in width, at its widest part extending 10 mm. posterior to beak. No distinct lunule observed.

Locality and Horizon. From the Meaford at Clay cliffs.

Whitella securiformis Foerste ?

Plate XXVI, Figure 5; Plate XX, Figure 3 *a-e*

Whitella securiformis Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 299, pl. 1, fig. 1.

The type of *Whitella securiformis* is characterized by its subquadrangular outline, considerable height compared with length, narrowness of post-umbonal part of shell, and moderate convexity of valves even along the umbonal area. Posterior margin of shell comparatively straight except where rounding into the hinge-line, forming an angle of about 80 degrees with the latter. Basal margin only moderately oblique, resulting in a considerable height of that part of the shell anterior to the beak. Beak occupies a position about half-way between anterior margin of shell and posterior end of hinge-line. Umbonal ridge curves rather strongly downward within a short distance of hinge-line. Anterior outline of the shell broadly, rather than narrowly, convex.

Compared with *W. compressa* Ulrich, from the Black River of Minnesota, this species has a straighter posterior margin, a less oblique umbonal ridge, and a higher anterior outline. Compared with *W. quadrangularis* (Whitfield), from the Waynesville, of Ohio, valves are much less convex, beaks less prominent, and general outline less rotund.

Compared with *W. ohioensis* Ulrich, from the Waynesville, Ohio, valves much taller and more quadrangular in outline, postero-ventral angle being a much shorter distance back from front of the valve, posterior outline much more erect, antero-ventral outline descending much farther below the hinge-line.

Compared with *W. subovata* Ulrich, from the Waynesville, Ohio, outline more quadrangular, postero-ventral angle definitely outlined. Anterior to this the ventral margin rises more gradually, and greatest convexity of anterior margin is nearer mid-height along this margin.

Locality and Horizon. Huron river, west of St. Jean Baptiste, Que., in strata containing also *Pholadomorpha pholadiformis* (No. 8420). Probably in lower part of the Richmond.

Ste. Monique Specimens. Near Ste. Monique, occur numerous *Whitella,* more or less crushed, which either are identical with *W. securiformis,* or which apparently present a similar outline (No. 8546). Many specimens from this locality attain a height of 50 mm., and a length of about 60 mm. In one of the more oblique specimens the height is 40 mm., length about 55 mm. In both the more rotund and the more oblique specimens umbonal ridge makes an angle of about 60 degrees with lower, straight margin of hinge-area; but in the more oblique specimens, growth extended farther along umbonal ridge, and less along ventral margin, the latter being of very moderate convexity, whereas in the more common rotund forms acceleration of growth was less along umbonal ridge and more along the more anterior parts of ventral margin, producing a more quadrangular outline.

Shell itself frequently 1 mm. thick, although thicknesses of half to three-quarters of a millimetre are more common. Shell substance is whitish and calcareous, but at or next to the surface is a thin, black, chitonous film. Toward the hinge the shell is thicker than elsewhere.

Hinge-area striated distinctly with numerous, fine, longitudinal lines. Greatest height of area directly beneath the beak and for about 10 mm. posterior to same; here its height frequently reaches 3·5 to 4 mm. Posteriorly, height of the area decreases rather gradually, but anterior to beak, within 4 mm., height of the area decreases rapidly to 1·5 mm., and then diminishes more gradually as far as its anterior end. Beginning about 3 mm. anterior to the beak, a sort of flexure extends obliquely forward from the upper toward the lower margin of the hinge-area, and anterior to this flexure the ligament evidently was not only narrower but thinner. Continuing in the direction of the flexure, a narrow callosity extends forward, below level of lower margin of hinge-area, then more directly forward, reaching anterior margin of shell a little over 2 mm. below lower margin of this area. Between this ridge-like callosity and hinge-area is a deep depression, but it has not been possible to ascertain whether this groove serves for the reception of a hinge-tooth. Beneath the posterior extremity of hinge-area, are two oblique narrow ridges, occupying the position of postero-lateral teeth. They are about 10 mm. long, anterior tooth being a little over 2 mm. from posterior edge of shell. It has not yet been proved that these supposed postero-lateral teeth, from opposite valves, actually interlock.

Surface of shell concentrically striated and marked by growth lines. Umbonal ridge rounded, not strongly developed, indicated chiefly by more rapid convexity of shell, and moderate flattening of post-umbonal slopes. This low umbonal ridge is in striking contrast with more prominent ridge of most other species of *Whitella.*

Locality and Horizon. The Ste. Monique specimens here described occur at 60, 80, and 92 feet above that part of the Waynesville, in Nicolet River section, where *Strophomena planumbona* and *Rhynchotrema perlamellosa* occur in same layer. Most common between 100 and 105 feet above this lower horizon. They range from lower part of *Strophomena hecuba* zone to a short distance above its top.

Similar specimens of *Whitella* occur also in the *Pholadomorpha* zone of the Lorraine in Nicolet River section, and also 132 and 355 feet below top of *Leptæna* zone, but there is not at hand sufficient material from these lower horizons to determine their relationship to *W. securiformis.*

Whitella complanata Foerste

Plate XXIX, Figure 2; Plate XXI, Figure 3

Whitella complanata Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 300, pl. 1, fig. 2.

The type specimen is a strongly flattened left valve, flattening due to crushing. Judging from the shell in present condition, original outline strongly oblique, and original convexity moderate, excepting possibly near the beak. Basal or ventral outline gently convex for most of its length, rounding rapidly into the posterior border, but much more broadly into the anterior one.

Compared with *W. obliquata,* from the Waynesville, of Ohio, shell is more elongate in a direction parallel to umbonal ridge, and ventral margin straighter, umbonal ridge lower and less angular, especially toward beak, umbones larger and nearer the anterior margin.

Compared with *W. ohioensis* Ulrich, also from the Waynesville, of Ohio, umbones more tumid, and nearer anterior margin of shell. Umbonal ridge much less angular.

At the same horizon as *W. securiformis* in Nicolet River section, occasional specimens occur resembling *W. complanata* in outline (No. 8565).

Specimens from *Cryptolithus* zone at St. Hugues, resembling *W. complanata* in outline, probably belong to some other species.

Locality and Horizon. Huron river, west of St. Jean Baptiste, probably in Waynesville member (No. 8421). Also at same horizon at St. Hilaire.

Whitella complanata moniquensis var. nov.

Plate XXI, Figures 1, 2

Similar to *W. complanata* in its tumid umbones, located near anterior margin of the shell, in relatively low convexity of umbonal ridge, and in general outline. Differing chiefly in greater convexity of ventral outline, and in correspondingly greater height of shell.

Very similar in outline to *W. ohioensis* Ulrich, from the Waynesville, but umbones much more tumid, and farther toward the front. Moreover, shell slightly taller.

Locality and Horizon. Proetus zone, Lorraine, Nicolet River section, 725 feet below level at which *Rhynchotrema perlamellosa* and *Strophomena planumbona* occur at same horizon (No. 8548).

A similar specimen occurred in *Pholadomorpha* zone, 125 feet below the *Rhynchotrema perlamellosa* layer mentioned above (No. 8547).

Other specimens of *Whitella* occurred at the 1,035, 1,190 and 1,285-foot levels, all in *Leptæna* zone, same section. Of these, a specimen at the 1,035-foot level (No. 8549) resembled *W. complanata* in the weakness of umbonal ridge and in strongly anterior location of beak.

Whitella obliquata Ulrich

Plate XVII, Figure 13

Whitella obliquata Ulrich, Geol. Minnesota, 3, pt. 2, 1894, p. 565, pl. 40, figs. 31, 32.

Shell obliquely subrhomboidal ovate in outline. Beaks, considering their size, prominent; umbonal ridge angular and strongly defined, cardinal slope concave. Anterior part of shell extending distinctly in front of beaks. Umbonal ridge, though prominent, deviates at an angle of only about 30 degrees from hinge-line, causing the cardinal slopes to be much narrower than the general body of the shell. Ventral outline deviates only slightly from hinge-line in direction, and notwithstanding the strong obliquity of upper posterior margin, shell as a whole appears short, especially as compared with such shells as *W. sterlingensis*.

Locality and Horizon. Originally described from Waynesville, Ohio, but also identified from same horizon in Indiana, and from the Maquoketa in Minnesota.

Forms similar in outline, but probably belonging to different species, occur in *Proetus* zone, Lorraine, and in *Pholadomorpha* zones of Nicolet River section, at St. Hilaire, and at Streetsville.

Whitella hindi (Billings)

Plate XXI, Figure 4 *a, b, c*

Cyrtodonta hindi (Billings), Pal. Foss., 1, Geol. Surv., Can., 1865, p. 151, figs. 131 *a, b.*

Hinge-line relatively short; outline very oblique; umbones large; umbonal ridge angular along entire length, forming an angle of 50 to 55 degrees with hinge-line. Post-umbonal slopes relatively narrow, posterior margin of shell strongly oblique, and subparallel to umbonal ridge. Basal outline also strongly oblique, forming an angle of 40 to 45 degrees with posterior outline of shell. Anterior part of shell projects prominently forward beyond beaks, forming a relatively acute angle with hinge-line. Outline rather acutely rounded both at anterior and posterior extremities.

Length 65 mm., height at posterior extremity about 40 mm., convexity of a single valve about 17 mm.

Type specimen evidently is distorted obliquely so that the umbonal ridge of the right valve is fairly evenly convex, whereas that of the left has become strongly angular, especially toward beak.

In general outline this species resembles *W. sterlingensis* (Meek and Worthen), described a year later than *W. hindi.* It differs chiefly in the considerable prolongation of shell anterior to beak; it is assumed the umbonal ridge originally was less angular.

Locality and Horizon. Near Toronto, probably from *Pholadomorpha* zone (No. 2080).

Whitella sterlingensis (Meek and Worthen)

Plate XVII, Figure 14 *a, b*

Whitella sterlingensis Ulrich, Geol. Minnesota, 3, pt. 2, 1894, p. 567, pl. 41, figs. 27, 28.

Outline rhomboid ovate in form. Umbonal ridge strongly oblique, forming angle of about 135 degrees with hinge-line. Hinge-line relatively very short, so that the posterior margin of the shell also is very oblique, forming an angle of about 125 degrees with hinge-line toward the abruptly rounded lower posterior angle of the shell. Transverse outline of shell gibbous. Beaks prominent, and umbonal ridge strongly angular along entire course, leaving the cardinal slopes distinctly concave anteriorly and flattened posteriorly. Anterior margin extends a moderate distance in front of beaks.

Locality and Horizon. Originally described from the Maquoketa member of the Richmond at Sterling, Illinois, but also identified from Minnesota.

A form with a similar outline, but probably belonging to another species, was found in the Lorraine, *Pholadomorpha* zone, St. Hilaire.

Whitella torontoensis Stewart

Plate XXII, Figure 13

Whitella torontonensis Stewart, 29th Rept. Ontario Dept. Mines, pt. 6, 1920, p. 17, pl. 2, fig. 5.

Hinge-line projecting forward considerably beyond beak. Anterior outline broadly rounded, meeting hinge-line in a subrectangular manner, but rounding gradually into the very moderately convex basal margin. The latter forms an angle of about 10 degrees with hinge-line. Lower posterior angle narrowly rounded. Lower three-fifths of posterior outline forms an angle of 60 degrees with basal margin; upper two-fifths of this posterior outline curves more strongly forward, forming angle of about 45 degrees with basal margin. At an earlier stage of growth, when the type specimen had a maximum length of 57 mm., measured from upper anterior to lower posterior angle of shell, lower posterior angle was much less acute, owing to two factors: the less oblique posterior outline, and the greater convexity of basal margin. At a younger stage of growth, therefore, outline of this type specimen was similar to that of *W. complanata moniquensis*, but the umbonal ridge was more sharply defined, beak rose more narrowly above hinge-line, which extended farther forward from beak. It is evident that at younger stages of growth the outline was more subquadrangular, and that, at later stages, growth was greatest at lower posterior angle, fairly great along adjacent parts of basal and posterior margins, much less along upper anterior margin, and least along upper posterior margin, so that with advancing age shell became much more acute at lower posterior margin, and more obtusely angular at upper posterior margin. Umbonal ridge quite angular. Near beak forming an angle of about 130 degrees with hinge-line, decreasing to 125 degrees along middle of valve.

Greater part of shell, for a height of 38 mm., very weakly undulated in a concentric manner along body of shell; post-umbonal part finely but faintly striated, and along its anterior margin the striations are a little stronger. At later stages of growth, however, striations and undulations become much more distinct, though not coarse.

Judging from the lithological appearance of the rock, the type of *Whitella hindi* (Billings) was obtained in rock of the same age as the *Pholadomorpha* zone, Weston, Ont. From this species, *W. torontoensis* differs in having much smaller beak, upper anterior angle more subrectangular, basal margin less oblique, posterior part of hinge-line relatively long, and lower posterior angle less acute and less narrowly rounded. Judging from present condition of type specimen, it was distinctly less convex, especially along umbonal ridge, and latter was less angular.

Locality and Horizon. Near Toronto. Judging solely from the appearance of the rock, which is dark and shaly, the type was obtained in rock of the same age as that in *Leptæna* zone, Lorraine, Don Valley brickyard (No. 1033, H.R., Royal Ontario Museum).

Whitella goniumbonata Foerste
Plate XXIX, Figure 3

Whitella goniumbonata Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 301, pl. 1, fig. 3.

Shell small, short, subrhomboidal. Beak nearly terminal, enrolled toward hinge-line so as to produce along anterior margin a concave anterior area 11 mm. long and 2 mm. wide on the single valve. Present convexity of single valve about 5 mm., but original form of shell probably was more ventricose, producing more prominent umbonal area and greater width for anterior concave area. Umbonal ridge, at junction with cardinal slope, angular, angle being sharply defined from beak for about 17 mm. toward lower posterior angle of shell, and then becoming more rounded. Concentric striæ rather faintly defined. Faint radiating grooves are present on that part of shell anterior to umbonal ridge, dividing the surface into faint, radiating plications.

Locality and Horizon. From specimens labelled Huron river, collected Oct., 1872, by Thomas Curry. In the Waynesville (No. 8426). Also at same horizon in a creek about one mile southwest of Vars (No. 8474).

Miss Stewart figures from the lower 8 feet of the Don brick-yard a form of *Whitella* evidently belonging to the same group as *W. goniumbonata.* Compared with the type of that species, however, the body of shell anterior to umbonal ridge is not equally inflated, thus giving antero-ventral parts of shell a very different slope and outline. Moreover, the radiating plications ornamenting preumbonal slope are much more clearly defined.

The remarkable series of *Whitellæ* figured by Miss Stewart from the lower 8 feet at the Don brick-yard, including *W. impressata, W. lata, W. parksi, W. acutiumbonis,* and *W. radiata,* is a notable contribution to our knowledge of Ordovician lamellibranchs.

Whitella impressata Stewart
Plate XXII, Figure 9 *a, b, c*

Whitella impressata Stewart, 29th Ann. Rept. Ontario Dept. Mines, pt. 6, 1920, p. 19, pl. 2, figs. 2, 3, 6.

Three specimens figured on the plate accompanying original description (Plate 2) are figured in the present publication in the same consecutive order. Of these the first does not preserve the cardinal outline, anterior margin is defective, and valve is flattened by pressure, especially along umbonal part, but its relationship to the other two specimens is evident. Body of valve and its post-umbonal slopes marked by numerous very fine and faint concentric striæ and by low concentric wrinkles occurring at nearly equal intervals, most distinct on post-umbonal slope. Anterior half of body of valve marked by four distinct and one very faint, shallow groove. Measured horizontally along mid-height of valve parallel to cardinal margin, faint groove is 10 mm. from posterior margin, and in front of this the distinct grooves occur successively at intervals of 3, 1, 2, and 2 mm.

In second specimen the outline is much better preserved. Posterior outline and posterior two-thirds of basal outline only slightly convex, and form an angle of about 65 degrees with each other. Radius of curvature of outline at lower posterior angle of valve 7 degrees; along lower anterior outline it is 20 degrees, this outline rounding rapidly into the cardinal one. Hinge appears to be only 20 mm. long, upper posterior margin rounding into posterior outline with a radius of curvature of 20 mm. Here, again, concentric wrinkles more distinct on post-umbonal slope. Umbonal ridge distinct only toward beak, rounding into the general convexity of valve toward lower extremity. It forms an angle of about 65 degrees with hinge-line along middle valve. Only two grooves distinctly marked on body of valve, both near anterior end. Of these the more distinct is 12 mm. in front of posterior margin of umbonal ridge, measured along mid-height of valve, and the less distinct is 2 mm. farther toward front.

Third specimen also preserves outline very well. Length of hinge-line 20 mm., angle between latter and umbonal ridge also about 65 degrees along middle of valve. Umbonal ridge more distinct along lower part. This valve closely resembles the second specimen, but the radiating striæ more numerous. Measured along mid-height of valve, there is a very faint groove 6 mm. anterior to posterior margin of umbonal ridge, preceded by two faint grooves at intervals of 2·7 and 2 mm.; next by a very distinct groove at an interval of 1·8 mm., and lastly by a groove of intermediate distinctness at an interval of 1·5 mm.

Distinguished by short hinge-line, strong obliquity, considerable elongation along umbonal ridge, rapid rounding at lower end of posterior margin, and distinctness of radiating grooves. These grooves it shares with other species, as may be noted on accompanying plate.

Locality and Horizon. Lower 8 feet of the Don brick-yard (No. 1011 H.R., Royal Ontario Museum).

Whitella parksi Stewart
Plate XXII, Figure 7

Whitella parksi Stewart, 29th Ann. Rept. Ontario Dept. Mines, pt. 6, 1920, p. 19, pl. 1, fig. 17.

Right valve, closely resembling the second published figure of the series accompanying the original description of *W. impressata*, from the same horizon and locality (Plate XXII, figure 9 *c* of the present publication), but the valve is flattened by pressure, especially its umbonal part, which has been crowded forward over and conceals upper anterior part of valve, obscuring similarity of outline at this point. Resemblance continues to hinge-line, which is short, and the umbonal ridge, which has same obliquity and only a moderately greater angularity. Differences associated chiefly with surface markings. No corresponding concentric wrinkling, and any radiated grooving is extremely weak and lies far to the front.

Locality and Horizon. Six-foot level, lower Lorraine of Don brick-yard (No. 1013, H.R., Royal Ontario Museum).

Whitella lata Stewart

Plate XXII, Figure 12

Whitella lata Stewart, 29th Ann. Rept. Ontario Dept. Mines, pt. 6, 1920, p. 19, pl. 3, fig. 7.

Left valve 29·5 mm. long, parallel to hinge-line, 25 mm. high between base and hinge-line, and 27 mm. high as far up as beak, 29·5 mm. diagonally from beak to most distant part of valve along umbonal ridge. Convexity 7 mm., originally probably nearer 8 mm. General outline ovate-rotund. Radius of curvature of basal and posterior outlines 15 mm., changing to 10 mm. at lower end of umbonal ridge. Along lower anterior margin, curvature moderate, but at upper anterior angle outline curves rapidly into cardinal margin. Umbonal part broad, flattened by pressure, separated only by relatively narrow concave area from upper anterior margin of valve, beaks strongly incurved. Umbonal ridge forms an angle of 65 to 70 degrees with hinge-line; fairly distinct toward beak, but rounds into general convexity of valve below centre of valve. Anterior to umbonal ridge are six radiating shallow grooves separating radiating plications of much greater width. Measuring along mid-height of valve, posterior groove is 4·5 mm. anterior to posterior margin of umbonal ridge, intervals between other grooves being successively 1·8, 1·2, 1·3, 0·8, and 0·75 mm. Posterior groove most distinct, anterior ones becoming successively fainter. Concentric striæ present, but, except a few, very faint.

Distinguished from *W. impressata*, from the same locality and horizon, by more rotund outline.

Locality and Horizon. Lower 8 feet of lower Lorraine at Don brickyard (No. 1012, Royal Ontario Museum).

Whitella acutiumbonis Stewart

Plate XXII, Figure 1 *a*, *b*

Whitella acutiumbonis Stewart, 29th Rept. Ontario Dept. Mines, pt. 6, 1920, p. 20, fig. 19 (not figs. 20, 21).

Type specimen consists of a right valve, whose umbonal part has been crushed flat, especially toward beak. It is accompanied by a left valve belonging to same species in which umbonal part much less flattened. Shell small, about 13 mm. along umbonal ridge, and characterized by shortness of length, measured parallel to hinge-line, compared with vertical height, the former being 10·5 mm. and the latter also about 10·5 mm. in type specimen. In its original state, shell evidently strongly convex, original convexity probably equalling 4 mm. Umbonal ridge was strongly angular, and separated the strongly convex anterior half of shell from the rather strongly concave posterior half. The ridge forms an angle of about 120 degrees with hinge-line. Considering small size of shell, umbonal part is large and curves strongly inward and forward at the beak. Lower posterior angle of outline nearly rectangular. Posterior margin broadly convex and relatively erect, curving forward on approaching hinge-line. Basal margin, anterior to lower posterior angle, also broadly convex, curving upward anteriorly so as to round rather rapidly on approaching upper part of anterior outline of shell. Concentric striæ most distinct on post-umbonal slope. Three to five radiating grooves mark the surface anterior to the umbonal ridge, lower end of anterior groove being 7·5 to 9 mm. from lower posterior angle of shell.

In discussing the various forms of Whitella assembled under the term *W. acutiumbonis,* Miss Stewart states that "some of these shells might be regarded as young forms of the species hereinbefore described." This list of species described earlier in her paper includes *W. torontoensis, W. goniumbonata, W. impressata, W. lata,* and *W. parksi.* Affinity of *W. acutiumbonis* appears to be greatest with *W. lata,* which shows the same tendency toward short length, strong convexity, well-defined umbonal ridge, concave post-umbonal slope, and radiating grooves on body of shell anterior to umbonal ridge. However, in our present state of knowledge of the species of *Whitella* from the Don Brick-yard locality, the separation of these small specimens under the name *Whitella acutiumbonis* seems fully justified.

Locality and Horizon. Lower 8 feet of the Don Valley brick-yard, in strata regarded as belonging to *Leptæna* zone of Lorraine. Rock of the same lithological appearance as that containing *W. torontoensis, W. lata, W. parksi* (No. 1014 H.R. Royal Ontario Museum).

Whitella radiata Stewart
Plate XXII, Figure 2 *a, b*

Whitella radiata Stewart, 29th Ann. Rept. Ontario Dept. Mines, pt. 6, 1920, p. 21, pl. 3, fig. 3.

Type is a complete shell, retaining both valves, and, notwithstanding its small size, appears to be a mature shell. Only slightly distorted, umbonal ridge of right valve being crowded slightly backward, that of left valve correspondingly forward. Species characterized by short length, considerable height, and great convexity. Length of hinge-line 12 mm.; one beak is 3 mm. back from anterior end of hinge-line, and the other 4 mm. Anterior margin makes an angle of 120 degrees with hinge-line; posterior margin about parallel to anterior margin. Basal outline has a radius of curvature of 10 mm., rounding more rapidly into posterior outline than into anterior one. Radius of curvature of posterior outline into the hinge-line 5 mm. Direct distance between anterior and posterior outlines 18 mm. Height measured vertically as far up as hinge-line 20 mm., one umbo rising scarcely 1 mm., the other 3 mm. above hinge-line. Each valve has a convexity of 8 mm. In both, umbonal ridges curve forward as far as the small beaks, which are curved downward close to hinge-line. Anterior to umbonal ridge the body of valves is evenly and strongly convex; posterior to the ridge, post-umbonal slope distinctly concave, especially toward beaks. Umbonal ridge of right valve diverges from hinge-line at first at an angle of 45 degrees, and then curves downward until at mid-height this angle is 80 degrees, and toward base of valve it even curves slightly forward. Umbonal ridge of left valve starts off at an angle of 60 degrees, but within 5 mm. from beak the ridge curves slightly forward. Escutcheon distinctly defined.

Post-umbonal slopes distinctly wrinkled in a concentric direction, wrinkles being very faint on body of shell. Body distinctly grooved in a radiating direction, grooves being very shallow and separating broader, but very low radiating plications. Six or seven of these grooves present on the right valve, the posterior ones being slightly closer together. There are traces of an equal number of grooves on left valve; on the umbonal part, these grooves are crossed by faint, evenly spaced, concentric wrinkles.

Lithologically the matrix of the type of *W. radiata* agrees with the two specimens of *W. acutiumbonis* figured by Miss Stewart[1] from the Don brick-yard, in the Lorraine (Plate XXII, figure. 3 *a*, *b*, of the present publication). The latter appear to be the umbonal and adjoining parts of much larger specimens which may belong to a different species. They agree with *W. radiata* in the strong forward curvature of umbonal ridge toward the beaks, small size of the latter and their strong downward curvature as far as hinge-line, strong and even convexity of the body of the valves, and strong concavity of the post-umbonal slope, especially toward the beak. But the valves appear to have been more elongate, especially posteriorly, and their umbonal ridges appear to have been directed distinctly backward as far as the lower posterior outline of the shell, approaching the latter at an angle of about 65 degrees with the hinge-line. Apparently these two specimens are distinct both from *W. acutiumbonis* and from *W. radiata.*

Locality and Horizon. Labelled as coming probably from Lorraine at the Don brick-yard, Toronto (No. 1002 H.R., Royal Ontario Museum).

Whitella huguesensis sp. nov.

Plate XXI, Figure 5 *a*, *b*, *c*

Outline rotund; umbonal ridge broadly convex, angular only in immediate vicinity of beak, merging into general convexity of the shell before reaching the centre of the valves.

Length 45 mm.; height 38 mm.; convexity of a single valve 11 mm.

Compared with *W. compressa* Ulrich, from the Black River, Minnesota, this species has a fuller, and less angular beak; a less angular and less oblique umbonal ridge; and anterior part of valve extends forward from beak for a shorter distance.

Locality and Horizon. Yamaska river, 2 miles northwest of St. Hugues, in Lorraine strata containing *Cryptolithus tessellatus, Triarthrus becki,* and *Leptæna invenusta* (No. 8585).

[1] Rept. of Ont. Bureau of Mines, vol. 29, pt. 6, Pl. 1, figs. 19, 20, 21.

Pterinea (*Caritodens*) *demissa* (Conrad)

Plate XXVI, Figure 3, Plate XXIX, Figure 10; Plate XXXI, Figure 12

Avicula demissa Conrad, Jour. Acad. Nat. Sci. Philadelphia, 8, 1842, p. 242, pl. 13, fig. 3.
Avicula demissa Hall, Pal. New York, 1, 1847, p. 292, pl. 80, figs. 2 *a*, *b*.
Pterinea demissa Foerste, Bull. Sci. Lab. Denison Univ., 16, 1910, p. 71, pl. 1, fig. 10.
Caritodens demissa Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 269, pl. 1, fig. 10, pl. 3, fig. 11.

Nicolet River Specimen. Height 55 mm., length 58 mm. along hinge-line. Anterior lobe short, extending about 4 or 5 mm. anterior to a continuation of anterior outline of body of shell. Posterior wing relatively long and acute, extending about 15 mm. posterior to inner part of concave posterior outline of body of shell.

Outline of shell varied with age. In the mature specimen here described the main axis of the body forms an angle of 65 degrees with hinge-line, but at an early stage of growth this angle began as 55 degrees and changed to nearly 75 degrees in latest stages, 65 degrees being the average result. In the same manner, the anterior outline of body, exclusive of wing, in mature specimen forms an angle of about 77 degrees with hinge-line, but at early stages of growth angle was nearer 66 degrees. At all stages of growth posterior margin was concave between body and posterior wing, but the form of posterior outline varied considerably. At an early stage of growth, lower half of posterior margin curved slightly outward or was nearly vertical and angle made between lower margin of posterior wing and hinge-line approximated 45 degrees. With increasing age, posterior outline of body became more nearly parallel to anterior outline, finally surpassing same in its forward slope, until angle with hinge-line became 60 degrees. At same time, posterior angle of posterior wing became much more prolonged and acute, and retral angle between body and wing became deeper.

This means that the shell accelerated in growth most in a direction parallel to axis of body during earlier stages and also along upper part of posterior wing. Growth was least along upper half of anterior margin of the body, and at later stages it was retarded also along the retral angle.

Thus it will be seen that small specimens appear so different from mature ones as to suggest their belonging to different species.

In the Waynesville member, in the Nicolet River section, specimens of *Pterinea demissa* retaining the shell are not rare. Shell material forming left valve consists of two different substances. Main body of shell, forming all except surface film, is whitish in colour and mostly is about 1 mm. in thickness, though some parts of some shells exceed even 2 mm. Outer chitinous film black. Ligamental area about 2·5 mm. high and striated longitudinally. A lunate callosity faces interior of shell; its ends follow anterior and posterior outlines of upper part of main body of shell, and the narrowed crest of its arch rises to a level about 2 mm. below the striated ligamental area. Below and anterior to beak are several obliquely vertical teeth. Posteriorly, only posterior end of lunate callosity has been observed.

It was the writer's intention to figure the interior of the Nicolet River specimens, showing in what respect they differed from typical *Pterinea*, as founded on *P. lævis*. Unfortunately the specimens, and also the drawings based on these specimens, were lost in the Dayton flood, in 1913, and none has been found since. In these circumstances, the term *Caritodens*, with *P. demissa* as a genotype, cannot be regarded as well established, and future discoveries must be awaited in order to definitely establish its dental structure.

Caritodens. Pterinea was founded by Goldfuss on *Pterinea lævis*, a Devonian species from Nassau, Germany. This species has a broad, striated, ligamental area. Immediately below that area, interior of shell is thickened along an area whose inner outline is only moderately concave. Anteriorly, in front of apex of beak, three or four teeth incline diagonally upward and forward at fairly strong angles, and posteriorly there are two or three long linear teeth deviating but moderately from hinge-area.

This type of structure not known to exist among Ordovician forms usually referred to *Pterinea*, certainly not in the case of *P. demissa.*

Locality and Horizon. Nicolet River section, Lorraine, in the upper part of the *Pholadomorpha* zone (No. 8547).

Plate XXIX, figure 10, and Plate XXXI, figure 12, represent two specimens, Nos. 8429 and 8433 respectively, from Huron river, either from the Lorraine, *Pholadomorpha* zone, or from the Waynesville.

Type Specimen. P. demissa was described by Conrad from the Lorraine near Rome, N.Y., where it occurred in the lower part of the sandstones overlying the Lorraine shales.

Canadian Specimens. In the *Proetus* zone, *P. demissa* occurs in the Nicolet River section, Chambly Canton, and near Hawthorne.

In the *Pholadomorpha* zone in Nicolet River section, St. Hilaire, Weston, Streetsville, three-quarters of a mile south of Clay cliffs, and on the Bass Lake road southwest of Little Current.

In the Sheguiandah formation it occurs a quarter of a mile south of Clay cliffs.

In the Waynesville member it occurs on Snake island; in the Nicolet River section; at Huron river, St. Hilaire, Vars, Weston, Streetsville, Oakville, Clay cliffs, and at Kagawong falls. In the Kagawong member it occurs 3 miles southwest of Little Current, southwest of the Indian village, and 2 miles northwest of Gore Bay. In the fossiliferous layers of the Queenston red clay shales it occurs at several localities from 6 to 8 miles northwest of Meaford.

General Distribution. In addition to the New York and Canadian localities listed above, *P. demissa* ranges through the Maysville and Richmond formations of Ohio, Indiana, Kentucky, Tennessee.

Clionychia curta sp. nov.
Plate XXVI, Figure 4 *a, b, c*

This species most nearly resembles *Clionychia excavata* Ulrich, from the Whitewater, in the shortness of its cardinal margin. It is a smaller species, 18 to 20 mm. in length. Posterior margin straighter, and shell slightly narrower. Only concentric undulations and some very fine concentric striæ present. Upper anterior outline not well preserved in any specimen at hand, so that the characteristic curvature of the beak in *Clionychia* must be assumed.

Locality and Horizon. *Cryptolithus* zone, Lorraine, St. Hyacinthe, at the southeastern end of the exposures in the river below the dam (No. 8475).

Byssonychia vera Ulrich
Plate XXVIII, Figure 1 *a, b*

Byssonychia vera Ulrich, Geol. Surv., Ohio, 7, 1893, p. 629, figs. *a, b, c.*

Compared with *Byssonychia radiata,* this species is small, has a shorter hinge-line, more evenly convex valves, and a shorter byssal opening. Valves appear narrower, posterior outline less convex, and form cuneate ovate. Number of radiating plications about fifty. Owing to the greater narrowness of shell the plications are more crowded laterally and hence are more slender.

Locality and Horizon. Originally described from the Eden at Cincinnati. Similar specimens occur in the *Cynthiana* beneath the Eden, in central Kentucky.

Typical specimens occur in the limestones interbedded in the upper part of the Sheguiandah a short distance south of Clay cliffs and in the Burnett and McLean Hill sections south of Little Current.

Byssonychia vera is cited by Miss Stewart from the 6-foot level in the Humbervale quarry, Toronto.

Byssonychia hyacinthensis sp. nov.
Plate XLIII, Figures 1, 2

A form closely similar to *B. vera* occurs along Yamaska river at St. Hyacinthe, at the north end of the exposures below the dam. The number of radiating plications is the same, about fifty. It differs in being distinctly broader. In one specimen 24 mm. along the umbonal ridge; width of specimen, from anterior to posterior margin, 19 mm., instead of 17 mm. as in typical *B. vera.* Umbonal part more broadly rounded, beak less elongate, general outline more rotund, and anterior outline not so straight.

Byssonychia vera plana Stewart
Plate XXII, Figure 10

Byssonychia vera plana Stewart; 29th Ann. Rept. Ontario Dept. Mines, pt. 6, 1920, p. 25, pl. 1, fig. 26.

Left valve 30 mm. in height, measured diagonally from tip of restored beak to most distant part of basal margin; 21 mm. in width, measured from anterior margin to most distant part of posterior outline; convexity 5 mm. Anterior outline gently convex, except near byssal opening and toward beak where it is gently concave. Radius of curvature of the basal outline 10 mm., changing to 15 mm. along posterior outline. There are forty-three radiating plications.

Compared with the type of *B. vera* Ulrich, from the Eden near Cincinnati, Ohio, the anterior margin is straighter for a greater distance from beak, hinge-line slightly longer, convexity much less, resulting in a much narrower anterior aspect, beak less incurved, and more acuminate.

Locality and Horizon. From the Lorraine of Humber river near Toronto. (No. 345 H.R., Royal Ontario Museum) type.

Byssonychia radiata (Hall)

Plate XXXI, Figure 13 *a, b, c*; Plate XXVII, Figure 3 *a, b*

Ambonychia radiata Hall, Pal. New York, 1, 1847, p. 292, pl. 80, figs. 4 *a-l*.
Byssonychia radiata Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 273, pl. 3, figs. 12 A-C.

Anterior margin slightly concave along upper four-sevenths of height of shell, owing to arching forward of the beaks and incurvature of anterior face of shell toward byssal opening. The upper part of the umbonal ridge never tends to be abruptly angular in a transverse direction as in *B. richmondensis*. Angle between the anterior face and the cardinal margin usually varies between 85 and almost 90 degrees, but in some cases as low as 80 degrees. Length of the cardinal margin mostly about half the greatest length of the shell, from the beak toward the posterior part of the nearly evenly convex basal margin. In some, cardinal margin equals about three-fifths of greatest length of shell. Ratio of greatest width to greatest length, measured diagonally across the shell, from beak to posterior part of the basal margin, usually about 77 per cent, but may vary from 70 to 81 per cent. Convexity of single valve commonly not exceeding 6 mm. in a shell having a maximum length of 36 mm. Shells exceeding 40 mm. in length rare.

The number of radiating plications varies considerably. Shells in which both cardinal margin and anterior face are well exposed frequently have 45, 46, or 47 radiating plications. Specimens occur which have fifty-five plications. In the specimens with forty-five plications, plications distinctly broader than the intervening grooves; in those with fifty-five, width of the plication exceeds that of the intervening grooves only slightly, if at all. Between both extremes intermediate forms occur in the same layers of rock.

Wekwemikongsing Specimens. Numerous specimens of *Byssonychia* occur in the Lorraine exposure south of Clay cliffs, having about fifty radiating plications. Umbonal ridge rather evenly rounded since the flattening of the anterior face of the shell, around the byssal opening, is very moderate. However, the general outline and convexity of these specimens resembles that of typical *B. radiata* sufficiently well to permit their reference to that species (No. 8517).

Locality and Horizon. Originally described from the Lorraine formation of New York.

Canadian Localities. In the province of Quebec it begins its range at the top of the *Cryptolithus* zone, Nicolet River section, St. Hugues, St. Hyacinthe, and Breault.

In the *Leptœna* zone, in the Nicolet River section.

In the *Proetus* zone, in the Nicolet River section, Chambly Canton, Vars, and Hawthorne.

Most widely distributed in the *Pholadomorpha* zone, occurring in the Nicolet River section, St. Hilaire, Weston, three-quarters of a mile south of Clay cliffs, and on the Bass Lake road south of Little Current.

Similar forms, not known to be specifically the same, occur in the Waynesville in the Nicolet River section, at St. Hilaire, Huron river, Vars, Streetsville, 8 miles north of Meaford, and north of Manitowaning.

In the Kagawong similar forms occur north of Manitowaning, west of the Indian village southwest of Little Current, and northeast of Gore Bay.

In the Queenston red clay shales, similar forms occur at several localities northwest of Meaford.

Geographical Range. Outside of New York and the Canadian localities listed above, forms similar to *B. radiata* occur in the Maysville and Richmond of Ohio, Indiana, Kentucky, Tennessee, and Virginia.

It is not certain that all of these forms are specifically identical with *B. radiata* of the Lorraine of New York, but at present all as a rule are assigned to this species.

Byssonychia borealis sp. nov.
Plate XXVII, Figure 2 *a*, *b*, *c*

Outline similar to that of *Byssonychia radiata*, resembling especially the narrower forms of that species. Anterior margin slightly concave for a distance equal to five-eighths of maximum length of shell. Concave outline due chiefly to slight curvature of the beaks in a forward direction. Hinge-line about half as long as maximum length of the shell, or even a little shorter. Posterior margin more broadly convex than in typical *B. radiata*, giving the shell a relatively narrower aspect. Compared with that species, shell much more convex, especially along the umbonal ridge. In a specimen 58 mm. long the convexity of the single valve 17 mm.; in one 54 mm. long the convexity 12·5 mm. Upper half of the anterior face distinctly flattened by strong incurvature of the shell toward byssal opening, adjacent part of the umbonal ridge being angularly rounded, but not abruptly as in *B. richmondensis*. There are about forty-five plications, anterior view showing ten, lateral view the remainder. Specimens commonly do not exceed 50 mm. in maximum length, measured diagonally across the shell from beak to opposite side.

Compared with *B. richmondensis* beaks less acute and less prominent, the anterior edge of the umbonal ridge less angular, general outline of shell broader.

Compared with *B. præcursa*, shell larger, its general convexity greater, beaks more incurved, anterior outline straighter, and upper part of the anterior face flatter. Nevertheless, *B. borealis* is regarded as related more closely to *B. præcursa* than to any other species described so far.

Locality and Horizon. Clay cliffs, in the Richmond.

Byssonychia suberecta Ulrich
Plate XXVIII, Figure 3 *a*, *b*

Byssonychia suberecta Ulrich, Geol. Surv., Ohio, 7, 1893, p. 634, pl. 45, figs. 13, 14, 15.

Outline rotund ovate; beaks rounded, not prominent; lower half of anterior outline broadly convex, extending forward beyond the beak at an angle of about 105 degrees with hinge-line. Ratio of the width to the height as 5 to 6. Surface of shell rather evenly convex, convexity of the umbonal part being relatively broad, compared with that of other species. Number of radiating plications fifty-five to fifty-eight.

Locality and Horizon. From the Waynesville, Ohio and Indiana.

A similar form was identified by Ulrich from the *Pholadomorpha* zone, Lorraine, St. Hilaire.

Byssonychia grandis Ulrich
Plate XXVIII, Figure 5; Plate XXVII, Figure 4

Byssonychia grandis Ulrich, Geol. Surv., Ohio, 7, 1893, p. 631, pl. 46, figs. 6-9.

Specimens more strongly convex than in *Byssonychia cultrata*, less angular along umbonal ridge toward beak, number of plications only about forty.

Nottawasaga Specimen. Specimen closely resembling *B. grandis* in outline and in the number of radiating plications. Convexity of the specimen 6 mm. Thirty-three plications present, with room for several more. In this number of plications, the Nottawasaga specimen approaches that of *B. grandis*, which has forty plications, but plications in the former much more prominent and much more sharply defined laterally from the intervening grooves (No. 2120). Nottawasaga bay lies north of Meaford and Collingwood. The specimens could have come from the Lorraine, *Pholadomorpha* zone or from the overlying Waynesville. Since the rock is rather strongly calcareous, its origin probably was from some part of the Waynesville. *B. grandis* has been identified also from the Lorraine-like facies of the Waynesville, Streetsville, Ontario.

Locality and Horizon. From the Waynesville member of the Richmond formation at Oxford and Clarksville, in southwestern Ohio.

Byssonychia cultrata Ulrich
Plate XXVIII, Figure 6

Byssonychia cultrata Ulrich, Geol. Surv., Ohio, 7, 1893, p. 632, pl. 45, figs. 5, 6, 7.

Outline strongly concave anteriorly, especially along the byssal opening; beaks correspondingly acute and prominent. Upper part of anterior face almost flat. Lower part of anterior outline broadly convex, resulting in a quadrangularly ovate outline for the shell. Convexity about 15 mm. in a valve 70 mm. high, as contrasted with a convexity of 19 in a shell 60 mm. high in *B. grandis*, from the same horizon. Number of plications about fifty-five.

Locality and Horizon. From the Waynesville at Waynesville, Ohio.

Byssonychia praecursa Ulrich
Plate XXVIII, Figure 2 *a, b*

Byssonychia præcursa Ulrich, Geol. Surv., Ohio, 7, 1893, p. 633, pl. 45, figs. 1, 2.

Outline similar to that of *Byssonychia richmondensis*, but hinge-line longer and in some cases equalling greatest length of the shell. Specimen figured by Ulrich relatively narrow, but this is not the usual width of that species. Anterior face flattened, but not as strongly flattened as in *B. richmondensis;* it tends to be nearly vertical to hinge-line. Posterior outline only moderately convex, tending to be parallel to anterior face. General outline subquadrate. Number of radiating plications varies from thirty-eight to forty-two, about ten less than in *B. richmondensis.*

Locality and Horizon. Originally described from the Lorraine, Pulaski division, Lorraine, New York.

Byssonychia richmondensis Ulrich
Plate XXVIII, Figure 4 *a, b;* Plate XXVII, Figure 1 *a, b*

Byssonychia richmondensis Ulrich, 7, 1893, p. 632, pl. 45, figs. 3, 4.

Shell relatively large and tall. Beaks rather prominent, projecting slightly forward. Anterior outline slightly concave. Hinge-line short. Posterior outline broadly convex, general outline of the shell being quadrangular but narrow, width being about two-thirds of height. Anterior face strongly flattened, cardinal ridge being strongly angular. Radiating plications about fifty.

Locality and Horizon. Originally described from the Whitewater member of the Richmond formation, Richmond, Indiana.

Manitoulin Island Specimens. On Manitoulin island, east of the bridge leading to Barrie island, two specimens of a large *Byssonychia* were found in strata regarded as belonging to the Kagawong. Length, from the beak to opposite side, 70 mm. Anterior face of the shell flat, umbonal ridge being abruptly angular along its upper half. About ten radiating plications occupy anterior face of each valve, and remaining plications may have been forty in number, but the posterior part not preserved (No. 8515).

Opisthoptera fissicosta (Meek)
Plate XXVI, Figures 1, 2

Opisthoptera fissicosta Ulrich, Geol. Surv., Ohio, 7, 1893, p. 644, pl. 49, figs. 9, 11; p. 645, fig.

In outline and convexity similar to *Opisthoptera casei* (Meek and Worthen) from the Whitewater, but differing in having the radiating striations unequal in size, and apparently grouped into bundles of three, four, or five, especially on the posterior half of the shell. Anterior to umbonal ridge is a similar arrangement in groups, but along umbonal ridge the larger plications more frequently merely alternate with single smaller ones.

Locality and Horizon. Originally described from the Waynesville, southwestern Ohio.

In Ontario, specimens of *Opisthoptera fissicosta* occur in the Waynesville, at Streetsville, Oakville, Workman brook southeast of Meaford, on the Cape Rich road 6 miles north of Meaford, and at Clay cliffs.

A specimen from Cape Rich, numbered 2111, was collected by Robert Bell in 1859; it is from an arenaceous brownish rock, presumably the Waynesville. Another specimen, numbered 2112, from Hamilton, Ontario, evidently is a drift specimen from some point farther north. The matrix consists of a strongly calcareous limestone, also presumably from the Waynesville.

The specimens from Streetsville are of interest because they occur in the Lorraine-like strata along the creek just north of the railway bridge, associated with *Pholadomorpha pholadiformis*, and *Byssonychia grandis*.

Lyrodesma postplanum sp. nov.
Plate XLIII, Figure 10

Right valve with the posterior part of the shell missing. Judging from what remains, original length of the shell 23 mm.; height at the beak 16 mm. Beak 7 mm. back from the anterior margin, a distance almost equal to one-third of estimated length of the valve. Anterior angle of the valve low, about 9 mm. below the tip of the beak. Between the beak and this angle the upper anterior outline of the valve gently convex, with a radius of curvature of 15 mm. Basal margin has about the same radius of curvature, increasing slightly anteriorly, but the curvature at the anterior angle is rapid. The abruptly angular umbonal ridge forms an angle of 140 degrees from the beak for about half of its length and then curves posteriorly until angle becomes about 160 degrees. At the posterior end of ridge the outline of the shell is angular. Near the beak post-umbonal slope gently concave and curving inward so as to be invisible on direct view. Posteriorly this slope forms an angle of 25 degrees with an horizontal plane. Cardinal outline posterior to the beak gently concave for a distance of 15 mm. from the beak, with very weak angulation at the posterior end of hinge-plate. Width of the post-umbonal slope at its maximum 4·5 mm. No radiating plications or striæ present on this slope. Five radiating teeth on the hinge-plate, all free from the marginal part of the shell.

Compared with typical *L. major* Ulrich, from the Corryville member of the Maysville, Cincinnati, Ohio, beak and umbonal ridge more angular, height greater, and both anterior and posterior angles of the outline lower, nearer the basal margin.

Locality and Horizon. From Clay cliffs, in the Meaford.

Lyrodesma poststriatum (Emmons)
Plate XXV, Figure 10 *a*, *b*; Plate XLIII, Figure 9

Nuculites post-striatus Emmons, Nat. Hist. New York, Geol., 2, 1842, p. 399, text fig. 4.
Nucula poststriata Hall, Pal. New York, 1, 1847, p. 301, pl. 82, figs. 10 *a*, *b*.

Shell longitudinally triangular ovate; anterior outline evenly rounded; that part of the ventral outline posterior to the beak gently convex; lower posterior outline more rapidly rounded than any other part of the margin, but with no tendency toward angulation, as in other species of *Lyrodesma*. Upper posterior outline gently convex and curving forward strongly, merging into posterior part of short hinge-line. Umbonal ridge relatively straight along the upper half of its course, but along lower half curving progressively farther backward. Upper half of umbonal ridge strongly angulate, but its lower half with angulation less pronounced. Main body of the shell smooth or only faintly striated concentrically, concentric striæ sharply defined only along the anterior border. Along the post-umbonal slope the radiating striæ are crossed by concentrically arranged striæ readily visible to the eye. Five rather strong plications occupy the upper part of post-umbonal slope, directly beneath the sharp marginal border along the top of the ridge. Lower part of the post-umbonal slope occupied by three or four finer plications. In addition to these two sets of plications there is a tendency toward intercalation of still finer striæ, especially between the larger plications.

It is probable that more than one species passes under the name *L. poststriatum*. A closer discrimination of forms is necessary if these are to be of much service stratigraphically.

Type. *Lyrodesma poststriatum* was figured by Emmons,[1] in sets of figures including the following fossils:

Triarthrus beckii.

Nuculites scitula, extremely common immediately below Lorraine shales or in the upper part of the Utica slate. This species at present is regarded as identical with *Clidophorus planulatus*.

Nuculites poststriata, not a common fossil in Jefferson.

Avicula insueta, from the Mohawk valley. A species of *Pterinea* from Canajoharie, New York, evidently closely similar to *Pterinea demissa*, from strata formerly regarded as Utica, but possibly of lower Trenton age.

Lingula rectilateralis, associated with *Triarthrus*.

Judging from the context, this entire set of fossils was regarded by Emmons as of Utica age. Hall states that this species comes from both the shaly and arenaceous part of the Lorraine, which probably means that it comes both from the Eden fauna of the Lorraine and from the overlying typical Pulaski formation.

Locality and Horizon. Weston, Ontario, from the Lorraine, collected by J. B. Tyrrell (No. 2077). The specimen here figured and described from Weston is black, matrix resembling the Trenton limestone at Trenton Falls, New York. No rock of this colour is known to the writer in the

[1]Nat. Hist., New York, Geol. 2, 1842, p. 399, text figure 4 in set 110.

area around Weston, but a specimen of *Ischyrodonta unionoides westonense* (No. 2074), having the same lithological appearance, also is labelled as coming from Weston, although presented by a different person, Rev. J. M. Goodwillie.

Other Canadian Specimens. Miss Stewart figures from the 17-foot level at the Humber River cut, a left valve evidently of the same character as the specimen in the collections of the Geological Survey, Canada.[1]

A second specimen which she figures from the Don brick-yard,[2] has an umbonal ridge continuing acute and straight as far as the lower posterior angle of the shell. The upper part of the posterior margin is straighter and forms a more abrupt angle with the posterior cardinal line.

In the *Cryptolithus* zone at St. Hugues on Yamaska river, and at St. Hyacinthe occur forms resembling *L. postriatum.* Also in the *Proetus* zone at Chambly Canton, Vars, and Hawthorne, and in the *Pholadomorpha* zone about three-quarters of a mile south of Clay cliffs.

Lyrodesma poststriatum elongatum Stewart
Plate XXII, Figure 8

Lyrodesma poststriatum elongatum Stewart, 29th Ann. Rept. Ontario Dept. Mines, pt. 6, 1920, p. 27, pl. 4, fig. 4.

Left valve, length 28·5 mm., height 16·6 mm. "The variety differs from the type of the species chiefly in its more elongated form; the ratio of height to length in *L. poststriatum* is from 1 : 1·44, to 1: 1·56, whereas in this case it is from 1 : 1·77, to 1 : 1·81.

The anterior outline is straighter and the posterior cardinal margin is not deflected downward as in *L. poststriatum.*"

In the original description of this variety the comparison evidently was made with the figure of *L. poststriatum* presented by Hall from Pulaski, New York. The type had not been freed from the matrix by Hall so as to show its outline properly. On cleaning the specimen its anterior outline was found to be more broadly rounded; hinge-line parallel to length of shell; upper posterior margin formed an angle of about 135 degrees with hinge-line; and umbonal ridge formed an angle of about 140 degrees with the latter near the beak, changing to 150 degrees posteriorly. The ratio of height to length was about 15 to 25, or as 1 : 1·66. In this type there are four simple plications on the post-umbonal slope, immediately above the umbonal ridge, followed by fascicles of finer striæ.

Locality and Horizon. From the 17-foot level at the Humber River cut (No. 998, H.R., Royal Ontario Museum).

Lyrodesma poststriatum manitoulinense var. nov.
Plate XLIII, Figure 5

Left valve 22 mm. long, 13 mm. high, with beak about 8 mm. from anterior end. Compared with typical *L. poststriatum* valve is of smaller height, the basal outline distinctly less curved, posterior border of umbonal ridge curves more strongly downward at the beak and is correspondingly

[1] "Stratigraphy and Paleontology of Toronto and Vicinity," 1920, pl. 4, fig. 4.
[2] Loc. cit. pl. 4, fig. 5.

less inclined toward its posterior end. Adjacent to posterior border, on the post-umbonal slope, are four radiating plications distinctly more elevated than those nearer the hinge-line. They form a band 2·2 mm. in width at their posterior terminations. Above this band is an elongate area 1 mm. in width posteriorly, with a larger plication along the middle and a much finer one above and below. Above this is a band 2 mm. wide posteriorly with seven to nine striæ becoming successively fainter above, between which and the hinge-area for a width of 1·5 mm. there is an area within which no radiating striæ can be detected in the specimen at hand. Eight radiating teeth ornament the hinge-plate.

Locality and Horizon. From Clay cliffs, in the Meaford.

Lyrodesma major (Ulrich)
Plate XLIII, Figure 6

Cleidophorus major Ulrich, Jour. Cincinnati Soc. Nat. Hist., 2, 1879, p. 25, pl. 7, fig. 23. Corryville member of Maysville formation.
Lyrodesma major Ulrich, Geol. Minnesota, 3, pt. 2, 1894, p. 611, fig. 45 *a-g*. Waynesville member of Richmond formation.

Anterior margin rounded most rapidly at mid-height of shell, slightly convex above this level as far as the beak. Umbonal part rather broadly rounded along the cardinal outline. Posterior to the beak outline of the shell gently concave, inclining downward so as to produce an attenuated posterior end. Umbonal ridge only moderately divergent from the cardinal line, distinct near the beak but more or less rounded into the general convexity of the valve posteriorly. Post-umbonal slope marked by twelve or more, fine, radiating striæ, leaving a narrow area along the hinge-line unmarked.

Among a group of specimens found in the *Proetus* horizon at Chambly Canton, on Richelieu river, is one specimen very similar to the specimens figured and described by Ulrich, especially in the rounding of the umbonal ridge posteriorly. The shell, however, is shorter; the posterior outline less strongly rounded; the radiating striæ on the post-umbonal slope slightly coarser, numbering about ten, and there appears to be a coarse clavicular ridge 1·5 mm. in front of the beak, slanting backward at an angle of 85 degrees with the horizontal line. In the associated specimens, the radiating striæ on the post-umbonal slope are equally fine, but the umbonal ridge much more distinctly angulate, as in the species described next, *L. huguesensis*.

Locality and Horizon. Described originally from the Corryville member of the Maysville at Cincinnati, Ohio. More extensively described and figured later from the Waynesville, Clarksville, Ohio.

Lyrodesma huguesensis sp. nov.
Plate XLIII, Figure 7

Right valve 20 mm. long, 11 mm. high, with a convexity of 4 mm., beak being located 7 mm. back from the anterior margin. For several millimetres from the beak umbonal ridge forms an angle of about 130 degrees with the horizontal line, changing to 145 degrees for the remainder of its length. Umbonal ridge abruptly angular along its entire length. Angle at the posterior end of the post-umbonal ridge low, about 8 mm. below the beak. Posterior half of the basal margin nearly straight; anteriorly curving upward so as to produce a slight angulation along the anterior margin, about 6·5 mm. beneath the beak. Posterior to the beak cardinal outline straight for 9 mm., width of the post-umbonal area at this point 4·5 mm. Post-umbonal slope marked by fine, radiating striæ, the first five from the umbonal ridge occupying a width of 1·5 mm., the next three of 1 mm., the next of 0·6 mm., the total of ten occupying a width of 3·1 mm.; above this is an area 1 mm. wide within which no striæ are noticed.

The specimens here described differ from *L. major* Ulrich chiefly in the much greater angulation of the umbonal ridge, and correspondingly greater angulation of the posterior outline.

Locality and Horizon. From the *Cryptolithus* zone at the base of the Lorraine, Yamaska river, about 1½ miles below St. Hugues.

Similar specimens, with a more strongly curved basal outline, occur in the *Proetus* zone at Chambly Canton.

Colpomya cf. *constricta* Ulrich

Cf. *Colpomya constricta* Ulrich, Geol. Surv., Ohio, 7, 1893, p. 659, pl. 52, figs. 17-19.
Colpomya constricta Ulrich, Geol. Minnesota, 3, pt. 2, 1894, p. 523, fig. 41.

A right valve similar to *Colpomya constricta* in outline and in every known surface feature, including prominent umbonal ridge, distinct, broad, strongly oblique, mesial sulcus; concave form of the post-umbonal slope; strongly oblique posterior outline; and the tendency toward distant growth lines. The interior structure is unknown.

Locality and Horizon. Cryptolithus zone of the Lorraine three-quarters of a mile east of Breault, on the western side of Bécancour river; also at St. Hyacinthe.

Colpomya faba (Emmons)

Plate XXV, Figure 8

Nuculites faba Emmons, Nat. Hist. New York, Geol. 2, 1842, p. 385, fig. 5.
Modiolopsis faba Hall, Pal. New York, 1, 1847, p. 158, pl. 35, figs. 6 *a-d.*

Figure 6 *a* published by Hall presents about the same size and shape as the figure published by Emmons, but according to my notes it has an outline like *Colpomya.* It resembles the Lorraine form, but is more prominent at the beak, and its strongly curved mesial sinus has a more vertical direction.

Locality and Horizon. Near the base of the Trenton limestone at Watertown, New York, occurring also elsewhere in that state, and in New Jersey.

Colpomya faba pusilla Foerste

Plate XXX, Figure 11; Plate XXXI, Figure 4 *a, b*

Colpomya faba pusilla Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 275, pl. 2, fig. 10; pl. 3, figs. 4 *a, b.*

Greatest length of largest specimen known about 10 mm., cardinal margin straight for a distance of about 5 mm. posterior to the beak, rounding into the oblique posterior margin of the shell. There is considerable variation in the obliquity of posterior margin; in shells having a more vertical posterior margin, the length of the straight hinge-line posterior to the beak may equal nearly 6 mm., whereas in shells having a strongly oblique posterior margin the straight hinge-line may extend only slightly more than 4 mm. from the beak. Mesial sulcus strongly defined from beak to basal margin, deepest part forming an angle of about 70 degrees, with the cardinal outline varying in some shells to 60 degrees.. Anterior to the mesial sulcus the shell is only moderately convex. Posterior to the sulcus, along the umbonal ridge, strongly convex, convexity becoming almost angular toward the beak. Angle between the umbonal ridge and cardinal margin varies usually between 40 and 45 degrees. Anterior margin more narrowly rounded, extending about 2 mm. anterior to the beak.

Maximum length, measured diagonally, 10 mm.; height posteriorly between 5·5 and 6 mm.; height at beak about 4·5 mm., but varying slightly; convexity of single valve about 1·75 mm. in shells showing the strongest convexity.

Surface with very fine concentric striæ, visible under a lens. Interior with a small muscle scar near the upper anterior margin; hinge unknown, and hence the generic reference is based merely upon the resemblance of the general outline of this shell to *Modiolopsis faba* Emmons, a species at present referred to *Colpomya.*

Modiolopsis faba was figured by Emmons from the base of the Trenton formation at Watertown, New York. His figure most closely resembles that of figure 6 *a*, Plate 35, vol. I, of the Palæontology of New York.

Compared with typical *Colpomya faba*, the valves of the variety *pusilla* are relatively higher posteriorly and lower at the beak, owing to the stronger divergence of the basal margin from the cardinal outline, amounting frequently to 30 or 35 degrees; beak projects more distinctly above cardinal margin; cardinal part of anterior margin rises more nearly to the level of the straight cardinal outline posterior to the beak. The mesial sinus begins at the beak as a depression near the middle of the umbones; it tends to be more oblique than in *Colpomya faba*, but, as a matter of fact, the Lorraine form is scarcely distinguishable from the Trenton type.

Locality and Horizon. East of Pulaski, New York, west of the railway bridge, at the *Cryptolithus* horizon in the Pulaski formation. The original of figure 10, Plate II, of the original publication of this species, was lost during the Dayton flood, in 1912. This had been collected in the *Proetus* zone at Chambly. An impression of another specimen from the same locality is numbered 8430 in the collections of the Geological Survey, Canada.

Similar specimens occur in the *Cryptolithus* zone of the Lorraine at St. Hugues and St. Hyacinthe.

A typical specimen of *Colpomya faba pusilla* is figured by Miss Stewart from below the 8-foot level in the Don brick-yard.[1]

[1] "Stratigraphy and Paleontology of Toronto and Vicinity," 1920, pl. 5, fig. 2.

Colpomya ? sp.
Plate XLIII, Figure 3

Shell 20 mm. long measured along its longest axis, maximum height posteriorly 11 mm. Similar to *Colpomya constricta* Ulrich in general appearance, but umbonal ridge is more curved, deviating only moderately from the horizontal at the beak, and curving progressively farther downward, so that the posterior end of ridge descends farther below the level of that part of the basal outline which is rendered concave by the mesial sulcus. In consequence, the basal outline, as a whole, is more oblique in direction. Also, that part of cardinal margin posterior to the beaks is shorter, and curves less abruptly into the upper posterior margin. The interior structure unknown.

Locality and Horizon. From the cherty layers 2 miles southwest of Kagawong, on the road to Gore Bay. In the Kagawong.

Cymatonota parallela (Hall)
Plate XXV, Figure 2

Orthonota parallela Hall, Pal. New York, 1, 1847, p. 299, pl. 82, fig. 7 *c*, *b*.

The figures accompanying the original description presented by Hall include two species, one from the Pulaski shales, Pulaski, New York, the other, probably belonging to a different genus, from some unknown horizon at Cincinnati, Ohio. A comparison of the description of the figures as printed in the text with that published on the plate indicates that figure 7*c*, Plate 82, was intended to be figure 7 *a*. Evidently figures 7 *c* and 7 *b*, Plate 82, both from Pulaski, New York, were intended to be the types of the species, with which the Cincinnati specimen was merely correlated. All three figured specimens are in the American Museum of Natural History in New York city. The type, figure 7 *c*, was evidently originally prolonged posteriorly along the ventral margin farther than in the published figure, presenting a posterior outline similar to that of *Cymatonota recta* Ulrich, from the McMillan division of the Maysville, Cincinnati, Ohio. Figure 7 *b* represents a vertically crushed *Cymatonota*, the original being a much better specimen than the published figure suggests.

The original of figure 7 *c* is a cast of the exterior. The oblique wrinkles along the hinge posterior to the beak are much plainer than suggested by the published figure. Compared with *C. recta* Ulrich, anterior margin more narrowly rounded and the anterior part of its hinge-line, in front of the beaks, farther below the level of that part of the hinge-line posterior to the beaks.

Locality and Horizon. In the Pulaski shales of New York. Cited also from the Maysville formation, Cincinnati, Ohio.

Miss Stewart figures under the name *Cymatonota parallela* two right valves of a new species, one specimen from the 4-foot level in the old shale pits at Lambton, the other from Humber river. In both the anterior part of the shell extends forward from the beak at least one-fifth of the length, and its upper margin rises almost to the same level as its posterior part. The umbonal ridge is prominent, and the oblique wrinkles along the posterior part of the hinge-line are strongly defined.

Cymatonota pholadis (Conrad)

Plate XXIX, Figure 14; Plate XXXI, Figure 7

Orthonota pholadis Hall, Pal. New York, 1, 1847, p. 299, pl. 82, fig. 6.
Cymatonota pholadis Foerste, Bull. Denison Univ., 17, 1914; p. 291, pl. 1, fig. 14.

Hall reproduces the drawing prepared by Conrad from his type. This drawing suggests a much narrower type of shell than any known from the Pulaski shales of New York, the ratio of height to length being as 8·5 to 45 mm., or nearly as 1 to 5. Moreover, according to the drawing, the oblique wrinkles along the hinge-line are shorter and more numerous than in any known specimens from this area.

The specimen figured by the writer from the *Proetus* horizon at Chambly Canton[1] is the nearest approach to *Cymatonota pholadis* found so far. In it the ratio of height to length is about as 1 to 4. Miss Stewart figures a similar shell from the Don brick-yard at Toronto.[2]

Locality and Horizon. Similar specimens were obtained in the Lorraine, *Proetus* zone near Vars, and in the *Cryptolithus* zone in the Nicolet River section from St. Hugues, and from St. Hyacinthe. In the Nicolet River section a complete specimen, with the valve spread wide open, was found 50 feet below the lowest horizon containing *Strophomena planumbona* and *Rhynchotrema perlamellosum,* in strata referred to the upper part of the *Pholadomorpha* zone.

Cymatonota recta Ulrich

Plate XXV, Figure 1

Cymatonota recta Ulrich, Geol. Surv., Ohio, 7, 1893, p. 663, pl. 55, figs. 6, 7.

Specimens elongate, upper and lower margins parallel, ratio of height to length about as 3 to 11. Umbonal ridge low, and mesial sulcus almost obsolete. Anterior margin regularly rounded, posterior margin relatively straight and forming an angle of about 60 degrees with the ventral outline.

Locality and Horizon. Originally described from the McMillan division of the Maysville, Cincinnati, Ohio.

In the Nicolet River section, similar forms make their appearance first in the Lorraine, *Leptæna* layer, which occurs 147 feet below the top of the *Cryptolithus* zone, near the top of the *Proetus* zone, but most common in the *Pholadomorpha* zone. In the lower part of the Waynesville it is associated with *Catazyga.*

At Chambly Canton it occurs in the *Proetus* zone, and south of St. Hilaire it is found in the *Pholadomorpha* zone.

Cymatonota recta is figured by Miss Stewart from the Don brick-yard at Toronto.[3]

[1] Bull. Denison Univ. 17, pl. 1, fig. 14; No. 2085.
[2] "Stratigraphy and Paleontology of Toronto and Vicinity," 1920, pl. 4, fig. 6.
[3] "Stratigraphy and Paleontology of Toronto and Vicinity," 1920, pl. 4, fig. 9.

Cymatonota lenior Foerste
Plate XXIX, Figure 9

Cymatonota lenior Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 290, pl. 1, fig. 9.

Shell with the general aspect of a *Cymatonota*, but without the oblique wrinkles along hinge-line, posterior to the beak. Hinge-line straight for a distance of at least 37 mm. from beak, and possibly farther, rounding into the posterior margin. The latter is rounded. Basal margin straight as far as a point directly beneath the beak; thence curving upward toward anterior margin which is most convex near its junction with anterior part of cardinal outline. Shell enlarges only moderately posteriorly, basal margin being subparallel to the hinge-line. Umbonal ridge weakly defined even within 15 mm. of the beak, and rounding posteriorly into the general convexity. Concentric striæ most distinct along anterior parts of the shell, and also along base; less conspicuous along the posterior border; and rather indistinct along umbonal ridge and over most of the post-umbonal slope.

Length 70 or 71 mm., greatest height posteriorly 22 mm., height at beak 16 mm., extension of shell anterior to beak estimated at 12 mm., convexity of single valve about 4 mm.

Locality and Horizon. Huron river, collected in 1872 by Thomas Curry. Lorraine, in the *Pholadomorpha* zone or in the lower part of the Richmond formation (No. 8422). Similar specimens occur in the Waynesville, at St. Hilaire, and in *Pholadomorpha* zone at Weston.

Cymatonota semistriata Ulrich
Plate XXV, Figure 3 *a, b*

Cymatonota semistriata Ulrich, Geol. Surv., Ohio, 7, 1893, p. 663, pl. 55, figs. 6, 7.

Ventral margin curving evenly upward at its anterior end, meeting that part of the hinge-line anterior to the beak at an abruptly rounded angle, located about one-fifth of the length of the shell forward from the beak. Anterior part of the hinge-line only moderately below the level of the posterior part.

Locality and Horizon. Originally described from the Waynesville in southwestern Ohio. A somewhat similar shell, cited from the Lorraine, *Pholadomorpha* zone, St. Hilaire, may belong to a distinct species.

Modiolodon postriatus Foerste
Plate XXIX, Figure 7

Modiolodon poststriatus Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 294, pl. 1, fig. 7.

Cardinal margin slightly convex, joining posterior outline, rather abruptly, at an angle of about 65 or 70 degrees. The basal margin diverges from the cardinal margin at an angle of about 15 degrees, rounding rapidly into the posterior margin and into the anterior outline. Umbonal ridge rather poorly defined in the specimen at hand. Anterior muscular area sharply outlined. Posteriorly, above the umbonal ridge, shell strongly marked by striæ parallel to the posterior margin; about nine striæ in a length of 5 mm. Elsewhere on the shell there are only faint indications of concentric striæ.

Length 35 mm.; height posteriorly 20 mm.; height at beak 14 mm.; extension of shell anterior to beak about 3 or 4 mm. Similar in outline to *M. truncatus* (Hall) and *M. subovalis* Ulrich, but there is no evidence of teeth near the beak.

Locality and Horizon. One mile west of Vars, along the railway, and then half a mile northward along the road; in a slab containing also *Catazyga headi* (No. 8428).

Modiolodon (?) *kagawongensis* sp. nov.
Plate XXIII, Figure 9

Outline rhomboid oblong. Hinge-line long and projects a considerable distance in front of beak at about the same elevation as the part posterior to the beak. Ventral margin almost straight for a considerable part of its length forming an angle of about 20 degrees with the latter. Ventral margin curves gently upward toward anterior margin, but the latter is rather narrowly convex. Posteriorly the ventral margin rounds rapidly into the posterior margin, forming an angle of about 40 degrees with the latter. Posterior margin moderately convex, its upper part forms an angle of 40 degrees with the hinge-line. Beak apparently small, umbonal ridge very low and gently convex, and the surface comparatively smooth.

The shell of *Modiolodon* is covered by an integument which is preserved in fossil specimens in the form of a thin black film. No trace of such a film is present in the specimen at hand, but, since the latter is silicified, its absence does not constitute a diagnostic character. In the absence of any knowledge of the interior of this shell, its reference to *Modiolodon* is only tentative.

Locality and Horizon. From the Kagawong 2 miles southwest of Kagawong, on the road to Gore Bay.

Modiolopsis hyacinthensis sp. nov.
Plate XXIII, Figure 7

Similar to *Modiolopsis similis* Ulrich, from the Decorah member of the Black River in Minnesota, but much smaller, being about 15 mm. in length. The mesial sinus curves strongly, crossing the ventral margin almost perpendicular to its outline, the umbonal part of the umbonal ridge curving in the same general direction. Concentric striæ rather distant from each other.

Locality and Horizon. Lorraine, in the *Cryptolithus* zone, at the southeastern end of the exposures below the dam at St. Hyacinthe (No. 8473).

Modiolopsis anodontoides (Emmons)
Plate XXV, Figure 9

Modiolopsis anodontoides Hall, Pal. New York, 1, 1847, p. 298, pl. 82, fig. 3 *a*.

Three species were figured by Hall under his description of *Modiolopsis anodontoides*. Of these figure 3 *a*, Plate 82, represents a specimen from the Pulaski shale at Lorraine, New York, and is the original to which Conrad applied the term *Cypricardites anodontoides*. Figure 3 *b* is the original of *Cypricardites sinuata* Emmons. According to a label by Hall, this original of *Cypricardites sinuata* Emmons "proves to be the young of *Cimitaria recurva*, Hamilton group." Figure 3 *c* represents a form resembling *Cuneamya*, and is from the lower shaly part of the Lorraine at Rodman, New York.

Applying the term *Modiolopsis anodontoides* to figure 3 *a* alone, it will include those specimens only which occur in the Pulaski member of the Lorraine. This specimen is subelliptical lengthwise, and abruptly rounded at its lower posterior angle. Umbonal ridge strongly angular. Anterior to the ridge is a shallow mesial sinus. Upper posterior outline of the shell broadly rounded and forming an angle of about 145 degrees with the hinge-line. Height of the shell a little less than half the length. Beaks located one-fourth of length of shell from anterior margin.

Locality and Horizon. Originally described from the Pulaski member of the Lorraine formation, Lorraine, New York.

Modiolopsis borealis sp. nov.
Plate XXIV, Figure 4 *a-f*; Plate XXIII, Figure 5

Specimens oblong, narrowing anteriorly, ventral margin forming an angle of about 32 degrees with the cardinal one. A mesial depression extends from the beak obliquely downward and backward, producing a small but distinct concave curvature along ventral margin. Mesial sinus much more distinctly indicated on casts of interior of valves, than on their exteriors, and the umbonal ridge bordering the posterior margin of the mesial sinus similarly is angularly defined on casts of the interior, and only weakly indicated on the exterior surface. Evidently the shell is much thicker along the mesial depression than along the umbonal ridge. Immediately posterior to the anterior muscle impression, the thickness of the shell in some cases equals 2·5 mm.; this thickness may continue across the mesial depression as far as the anterior margin of the umbonal ridge, where the shell is much thinner; but this thickness increases again posterior to umbonal ridge, especially on approaching the upper part of the posterior outline of the shell.

As in *Modiolopsis concentrica*, post-umbonal slopes strongly and conspicuously striated in a direction parallel to the posterior margin, especially its upper posterior margin. Ventral half of shell concentrically striated to a much less conspicuous degree. The upper anterior quarter of the valves, including most of the umbonal ridge, only faintly striated. This unequal distribution of the concentric ornamentation is characteristic of the group of species to which *Modiolopsis borealis* belongs. No trace of this concentric striation is shown on casts of the interior of the valves.

Compared with *Modiolopsis concentrica*, shell much more elongated parallel to hinge-line, the umbonal ridge much less prominent and the mesial depression much more shallow on the exterior of most specimens.

Specimens very abundant in a layer 3 or 4 inches thick at the locality from which the types were obtained, and in the same layer occur specimens exposing the interiors assumed to belong to the same species. In these interiors, nothing corresponding to a tooth is present on the hinge-area. Area somewhat broader at the beak, then narrower for a few millimetres posterior to the beak, then broader again posteriorly. It is marked by a long, narrow, median line, with a groove both above and below the line, grooves serving probably for lines of attachment of external and internal ligaments. Immediately below the beak, begins the ridge defining the upper posterior part of the border limiting the anterior muscle impression. Impression deep. Pallial line begins at middle of base of muscle impression and continues posteriorly in a direction parallel to the base of the shell. It is crossed and crenulated by oblique striations and grooves with a general radiating direction between the anterior muscle impression and the posterior slope of the umbonal ridge. Shells which have been more or less exfoliated show these radiating grooves and striæ very well. They are most numerous on the umbonal ridge, but tend to occur at equidistant intervals.

Locality and Horizon. About three-quarters of a mile south of Clay cliffs, in the Lorraine-like strata containing *Pholadomorpha pholadiformis*, *Lyrodesma poststriatum*, *Clidophorus planulatus.*

Modiolopsis borealis postdeclivis var. nov.
Plate XXIV, Figure 5 *a*, *b*

Associated in the same layer of rock with the types of *Modiolopsis borealis* are other specimens, apparently of the same species, but less extended parallel to the hinge-line, posterior outline curving diagonally downward for a much longer distance, posterior height being greater, and angle between the ventral margin and hinge-line being more divergent, frequently equalling 35 to 40 degrees. Umbonal ridge has a correspondingly more oblique course; it is rather strongly developed near the beak and curves downward near its posterior end. Mesial depression distinctly developed, its lower half curving distinctly downward. Ventral outline varies from gently to strongly concave along mesial sinus.

The outline of this variety is closely similar to *M. concentrica,* but anterior part distinctly taller. Umbonal ridge and mesial depression equally developed, but the concentric striæ on the post-umbonal slopes far less distinct, numbering nine or ten in a length of 5 mm., instead of six, as in typical *M. concentrica.*

If it were not for the presence of numerous intermediate forms in the same rock layer, this variety would be regarded as a distinct species.

Locality and Horizon. Associated with *M. borealis*, about three-quarters of a mile south of Clay cliffs, in the Lorraine, *Pholadomorpha* zone.

Modiolopsis meafordensis sp. nov.
Plate XXIV, Figures 2, 3

Exterior of shell in outline and convexity appears to resemble closely those specimens of *Modiolopsis borealis* which have a weakly developed mesial depression. Anterior margin of shell, however, differs distinctly in outline. Upper margin of shell anterior to beak slopes less diagonally downward, being only slightly lower than the beak itself. Shell, as a whole, appears distinctly narrower anteriorly. Lower or ventral margin almost straight for greater part of its length, but a slight inward curvature present along margin of mesial depression. Mesial depression very shallow. As far as known, the cast of the interior does not show any elevation along the umbonal ridge as in the type of *M. borealis*. Part of the specimen preserves traces of the black film so often seen on the exterior of fossil specimens of the *Modiolopsidæ*, but there is no evidence of the strongly marked concentric striæ along the upper posterior margin of the shell as in the type of *M. borealis*. It may be that some of the differences noted are features belonging to the interior, rather than to the exterior of the shell; but, as far as may be determined from the specimens at hand, they present recognizable differences.

Locality and Horizon. From Cape Rich, 8 miles north of Meaford, in a rock resembling that of the Lorraine of this area. Rock of this type as a rule contains layers with *Pholadomorpha pholadiformis*, and may be of lower Waynesville age. Type, No. 2068.

Specimens of smaller size, somewhat similar, in the absence of any strong elevation parallel to the umbonal ridge on casts, are found along the lower part of McLean hill. They occur in strata containing *Pholadomorpha pholadiformis*, and having a Lorraine-like appearance, but possibly of lower Waynesville age (No. 8487 *a*, *b*).

Specimens similar in outline occur also at Clay cliffs.

Modiolopsis manitoulinensis sp. nov.
Plate XXIII, Figures 1 *a*, *b*, 6 *a*, *b*

Shell elongate parallel to hinge-line; ventral margin nearly straight along greater part of its length, forming an angle of about 13 degrees with hinge-line. Umbonal ridge fairly distinct near hinge-line, rounding posteriorly into general convexity of the shell. Mesial sinus sufficiently indicated to flatten the preumbonal slopes of the shell, in some producing a faintly concave outline along the anterior part of the ventral margin. General convexity of the valves moderate. Hinge-line, posterior to beak, relatively long, rounding rather abruptly into the oblique posterior margin. Concentric striæ distinctly defined along the post-umbonal slopes, relatively strong in well-preserved specimens.

Length of the largest, but imperfect, specimen 44 mm.; prolongation of shell anterior to beak about 9 or 10 mm.; height at beak 15 mm.; height at posterior end between 22 and 25 mm.; general convexity of single valve about 3 mm.

Locality and Horizon. Meaford member, Clay cliffs.

Modiolopsis concentrica Hall and Whitfield
Plate XXV, Figure 11 *a*, *b*

Modiolopsis concentrica Hall and Whitfield, Pal. Ohio, 2, 1875, p. 86, pl. 2, fig. 18.
Modiolopsis concentrica Ulrich, Geol. Minnesota, 3, pt. 2, 1894, p. 510, pl. 37, figs. 15, 16.

Shells triangularly elliptical in outline. Ventral margin forms an angle of about 25 degrees with the hinge-line. Anterior margin evenly and rather narrowly rounded. Lower posterior margin rounds almost as narrowly into the broadly convex posterior outline, which curves strongly forward at the top, merging almost imperceptibly into the outline along the hinge-area. This scimitar-like posterior outline is one of the characteristic features of the shell. Anterior part of umbonal ridge clearly defined, especially toward the beak, by the mesial sulcus. Although the latter is not deep it leaves its impress along the entire length from beaks to ventral margin. The latter mostly faintly concave in outline, owing to this sulcus. On casts of the interior the course of mesial sulcus is limited posteriorly by an umbonal elevation which is somewhat steeper in its course than the umbonal ridge as seen on the exterior of the shell. Anterior muscle scar clearly defined, and pallial line clearly outlined as far as the posterior part of the mesial sulcus. Surface of the shell ornamented by concentric striæ boldly marked along the post-umbonal slope, much less prominently indicated along lower part of the pre-umbonal slope, only faintly indicated along the middle and upper parts of the umbonal region, and directly anterior.

Locality and Horizon. Originally described from the Waynesville member of the Richmond formation in Ohio, but identified also from Indiana and Kentucky.

Modiolopsis concentrica chambliensis var. nov.
Plate XXIV, Figure 1

In the *Proetus* zone of the Lorraine exposed below the dam at Chambly Canton, there is a *Modiolopsis* strongly resembling *M. concentrica* in its outline and in the strong concentric striation of its post-umbonal slopes. It differs in having a weakly-defined umbonal ridge, and correspondingly weak mesial sinus. These differences might be due to flattening during fossilization, the specimens being preserved in shale. The Chambly form is distinctly larger. The varietal name *chambliensis* is proposed (No. 8563*a*).

Under the name *Modiolopsis concentrica* Miss Stewart figures, from the 17-foot level in the Humber River cut, a distinct species in which the hinge-line rounds into the posterior margin with a greater angulation, umbonal ridge and mesial sinus are less distinctly defined and their course is not so oblique, ventral margin more nearly straight, diverges less strongly from the dorsal one, the upper anterior outline less distinctly concave and has not the same obliquity. Among described species, this Humber River form resembles most nearly the *Modiolopsis simulatrix* Ulrich, from the Southgate division of the Eden formation, Cincinnati, Ohio, and vicinity, but its anterior outline is more prolonged.

Modiolopsis vera sp. nov.
Plate XXIII, Figure 3 *a, b, c;* Figure 2 *a, b*

Hinge-line moderate length, shell elongate, umbonal ridge forms an angle of about 45 degrees with hinge-line. It tends to be angular toward the umbones, where its anterior face is flattened by the broad but shallow mesial depression. Posteriorly, it remains prominent along the mesial depression. Anterior outline of the shell projects about 5 mm. in front of beak, and is separated from it by a rather faintly concave marginal interval. Hinge-line meets the posterior margin at a slight angle.

The strong obliquity of the shell, the prominence of the umbonal ridge, especially along the umbones, and the faint surface striæ are the prominent characteristics of this species.

The relationship of this species to *Modiolopsis* is indicated by the faint mesial depression.

Locality and Horizon. In the silicified limestone 2 miles southwest of Kagawong, on the road to Gore Bay. In the Kagawong (No. 8518).

Apparently also at Clay cliffs, in the Meaford formation.

Modiolopsis brevantica Foerste
Plate XXIII, Figure 4 *a, b, c*

Modiolopsis brevantica Foerste, Bull. Denison Univ., 16, 1916, p. 332, pl. 5, figs. 1 A, B.

Hinge-line moderate length, shell elongated. The umbonal ridge forms an angle of about 40 degrees with the hinge-line. The ventral margin and the upper posterior margin are sufficiently parallel to the umbonal ridge to give the general outline of the shell a rhomboid appearance. Parallel to the umbonal ridge length of shell is about 32 mm.; the height at right angles to this line being 16 mm.; and the width of shell across both valves about 12·3 mm. Anteriorly the shell projects but a short distance beyond the beaks. The umbonal part is distinctly flattened, and enough depressed toward the ventral margin of the shell to cause a slight inward inflexion of the latter.

Shell coarsely striated concentrically, parallel to the margin of the shell, along its posterior parts, especially where crossing the umbonal ridge, where seven striæ occur in a length of 5 mm.

Locality and Horizon. Clay cliffs, in the Meaford (No. 8450).

Modiodesma n. gen. Ulrich, and the genotype of Modiolopsis Hall[1]

By E. O. Ulrich

The type of *Pterinea modiolaris* Conrad 1838, *Cypricardites modiolaris* Conrad 1841, belongs to the species which I am making the genotype of my new genus Modiodesma. Previously published illustrations of this specimen are inadequate and in some respects inaccurate. That given by Hall[2] is better than the one by Emmons, who figured it under the erroneous designation *Cypricardites ovata*[3]. The photographic figure published by Foerste[4] is some improvement on the preceding, but the specimen was so illuminated that the characteristic rather strong and regularly spaced concentric ribs on the anterior fourth or third are very imperfectly shown. This author also made a mistake in cutting out the matrix, for with it went some essential structural details pertaining to the hinge. A new figure (Figure 1) which it is hoped will correct these shortcomings is given on Plate XXXII.

Cypricardites angustifrons Conrad 1841, was founded on a specimen that is either a variety of *Modiodesma modiolaris* (Conrad) Ulrich, or a closely allied species differing mainly in the more angular anterior extremity and coarser concentric ribs. These peculiarities are not well exhibited in any of the figures of this specimen hitherto published. That by Emmons[5] is a generalized view in which the entire surface is uniformly covered with closely and regularly spaced concentric lines and the specimen is so posed that one gets a wrong impression as to the actual and original width (or height) of the valves. Hall's figure[6] is like Emmons' in the latter respect and further, makes the specimen appear more like a crushed example of *M. modiolaris* than the facts warrant. Foerste[7] improves on the older illustrations of this specimen, especially in showing the actual width of the right valve, but the anterior extremity is incorrectly represented and the surface markings appear more obscure than they are. It is hoped that Plate XXXII, figure 4, will supply these deficiencies. These illustrations are supplemented by a photograph of another larger specimen (Plate XXXII, figure 5) that preserves the surface markings in a more satisfactory manner. In *M. angustifrons* (Conrad), as will be observed by comparison with figure 1 in the same plate, which was made from the type of *Modiodesma modiolaris* (Conrad), the concentric ribs over the antero-ventral half of the shell are stronger and the anterior extremity more angular than in the genotype of Modiodesma.

Cypricardites ovatus Conrad 1841 (not Emmons 1842, who figured the type specimen of *M. modiolaris* (Conrad) under this name) belongs to the group of *Modiolopsis concentrica* which is distinguished by its ventral sinus and regular, strong, concentric ribs or lines on the postero-dorsal

[1] From a manuscript work on Ordovician and Silurian Pelecypods by E. O. Ulrich.
[2] Pal. N.Y., vol. 1, pl. 81, fig. 1*a*, 1847.
[3] Geol. of N.Y., pt. 2, p. 405, fig. 114-2, 1842.
[4] Bull. Denison Univ., vol. 17, pl. 5, fig. 1*a*, 1914.
[5] Op. cit., p. 405, fig. 114-1.
[6] Op. cit., pl. 81, fig. 1*b*.
[7] Op. cit., pl. 5, fig. 2*a*.

half of surface and not on the other half. Its group is a natural one with many species ranging from the Black River to the Richmond, and it should be distinguished as another genus. In fact, as will appear from the following argument, *M. ovatus* is best fitted to fill the role of genotype of *Modiolopsis* and will be so designated by me hereafter. The species seems to be a rather rare fossil in New York, but at Cincinnati in the Fairmount member of the Maysville it is not uncommon.

Hall in 1847 united these three species of Conrad (*Cypricardites modiolaris*, *C. angustifrons*, *C. ovatus*) and also other distinguishable forms under the single designation *Modiolopsis modiolaris*, being led to this course by the belief that all these forms are connected by intermediate and transitional specimens, a conclusion that is disproved by recent comparison of larger collections from New York and elsewhere. This conception of *Modiolopsis modiolaris*, which is mentioned by him as the genotype of his genus Modiolopsis and which he proposed in that year, is really a composite of three or more distinct species belonging to at least two and probably three distinguishable groups which are now regarded as entitled to recognition as distinct genera. In seeking to unravel the complex thus introduced by Hall the first step requires the solving of a series of most perplexing nomenclatural problems.

In the first place the composite nature of Hall's conception of *Modiolopsis modiolaris* must be recognized when he mentioned this species at the close of the generic characterization of his new genus Modiolopsis. In his estimation *M. modiolaris* was a most variable species. He applied this name not only to specimens that agree precisely with the one to which Conrad originally applied the name *Pterinea modiolaris* and two years later called *Cypricardites modiolaris*, but to a great variety of other forms that he regarded as belonging to the same species and which we now know are to be found together only by generic and family characters.

It may next be learned from a careful analysis of Hall's generic description of Modiolopsis just which characters of these shells impressed him the most. Quoting his description he says: "equivalve, inequilateral elongated, becoming broader posteriorly; umbones near the anterior extremity, which is marked by a single strong muscular impression as in *Modiola*." So far the characters are all of family value and correct except the misleading statement concerning the muscular scar. Proceeding he says: "a sinus often extends from the anterior side of the umbones, obliquely backwards, leaving the anterior portion separated as a kind of lobe. Surface marked by fine concentric striæ; shell thin." In his remarks he says further: "One of the most prominent characters is the strong muscular impression * * * . There is often a slight contraction or sinus below * * but this is not always conspicuous."

From the foregoing quotations it is clear that when Hall proposed the genus Modiolopsis he had in mind particularly those shells that are provided with a mesial depression and ventral sinus and a deeply impressed anterior muscular scar. Looking over the figures of *Modiolopsis modiolaris* published by Hall at this time[1] we find this combination of essential characters clearly exhibited only in figures 1 *e* and 1 *f* on Plate 81. Figure 1 *c* in the same plate has the required gently concave ventral edge, but being a cast of the exterior it gives no indication of muscular scar. However,

[1] Pal. New York, vol. 1, pls. 81 and 82.

casts of the interior of this form show that the muscular scar is large and deep. Figure 1 *b* is incorrectly outlined, and figure 1 *g* shows only the anterior end of an interior cast. In figures 1 *a* and 1 *b*, the former of which is Conrad's type of his *Cypricardites modiolaris*, the ventral outlines are distinctly convex, and there is no indication of the required oblique depression beneath the low umbonal ridges. Finally the small specimen figured on Plate 82, figure 1, is said to be a young shell. But it shows a well-developed umbonal ridge which Hall says Modiolopsis should not have. Besides I recognize it as a normal example of a species named by me many years ago as *Modiolopsis milleri*, the generic position of which is under consideration. Apparently it belongs to Colpomya.

Now, since it has become desirable to restrict the genus Modiolopsis and to employ other generic designations for well-characterized and constantly growing groups of shells that have hitherto found a more or less uncongenial place under Modiolopsis, the first decision to be made is which kind of shell is to be accepted as the genotype of the restricted genus. That the selection should be made from the seven specimens figured by Hall[1] as *Modiolopsis modiolaris*, the designated type of his genus, seems too obviously in accord with reason and nomenclatural law to require argument.

The easiest, but also the most thoughtless, selection of the genotype would be the specimen on which Conrad originally founded his species *Pterinea* or *Cypricardites modiolaris*. But if this were done only a fifth part of one of the fifteen species originally referred to the genus by Hall, namely, *M. modiolaris* (Conrad) Hall part, would be retained in the restricted genus, and only two of the ninety odd species that have been referred to Modiolopsis since 1847. This course would be objectionable, also, because the very features which, after the more general family characters, were particularly mentioned by Hall in the generic description, would not apply to the restricted genus but to other groups that were better represented in the material used by Hall in 1847 and which accord much better with the conception of *Modiolopsis* generally prevailing among authors since that date.

Moreover, if we are to be guided by the clearly expressed intent of the author of the genus, we must eliminate figures 1 *a*, 1 *b*, and 1 *d*. This narrows the field of candidates to figures 1 *c*, 1 *e*, and 1 *f*. At the same time it requires a change in the name of the genotype, for none of these specimens is strictly of the same species or even the same genus as *Cypricardites modiolaris* Conrad.

The remaining three candidates may be still further cut down, I believe with the consent of all palæontologists, by throwing out figure 1 *f*, which is based on a specimen from the Richmond group at Madison, Ind. The genotype should be a New York fossil, and the species to which this specimen (figure 1 *f* of Hall) belongs (*Modiolopsis valida* Ulrich) has not been found and probably does not occur in that state. Thus only figures 1 *c* and 1 *e* remain to be considered.

Figure 1 *c* is beautifully but somewhat incorrectly drawn, the beak being much too far from the anterior extremity of the valve. However,

[1] Pal. of New York, vol. 1, pl. 81.

so far as externals are concerned it would fill the requirements very well. The only structural objection is that it does not show the anterior muscular scar. But I know the form very well from study of good specimens found in New York and in the vicinity of Cincinnati; and most of these leave no doubt as to the depth and large size of the muscular scars. Indeed, a recent examination of the original of figure 1 *c* established that the anterior scar is not only present as usual but is indicated clearly enough to have been outlined by the draughtsman. Its internal characters, also, then, would meet the requirements.

But my strongest objection to the adoption of the original of figure 1 *c* as the genotype of *Modiolopsis* is that this particular form never has been given a specific name of its own. It was not included among the shells of this familty that were named by Conrad; and it is certainly distinct from them. Following Hall, authors and collectors have simply referred it to *M. modiolaris* without inquiry as to the strict propriety of the reference. In fact it has been so labelled more often than any other species of its family, it being the most abundant of these at Cincinnati. And it is not very rare in northwestern New York either. But it is widely different from Conrad's species, and as it deserves a name of its own I now propose calling it *Modiolopsis halli*. Remembering that Hall's figure of this shell places the low beak much farther behind the anterior extremity than it should be, this illustration of its characters will serve pending an opportunity to publish better figures of this and many other unnamed Pelecypoda that I have distinguished and named in manuscript during the past thirty years.

Thus we have eliminated all except one of the original claimants to the title of genotype of *Modiolopsis*. This is the specimen represented by figure 1 *e* on Plate 81 of Hall's work. On page 295 he states that this is the original of Conrad's *Cypricardites ovata*. As this specimen and species has every desired structural qualification—in fact it accords more exactly with the generic description than any of the other species that Hall referred to the genus in 1847; (2) as it is a New York fossil and one of those described by T. A. Conrad, the first palæontologist of the New York Geological Survey; (3) as it is one of the number of forms that were illustrated by Hall and included under his broad conception of *Modiolopsis modiolaris*, a name selected for the composite species, as he informs us, solely on the ground of priority; (4) as more of the species originally referred to the genus by Hall and also more of those described since 1847 are strictly congeneric with *M. ovata* (Conrad) than would be the case if any other of the five or six really distinct species that were combined by Hall in 1847 under the single designation *Modiolopsis modiolaris* were to be chosen for the position of genotype; also (5), as the first species to be described by Hall following the description of the genus, namely, *M. mytiloides*, is one of the few species of those originally referred to the genus that is strictly in accord with the generic diagnosis and also with *M. ovata;* and, finally (6), as none of the writers who have considered the generic aspects of *Modiolopsis* in the meantime has, if they were realized at all, made any such effort to unravel the nomenclatural complexities involved in the determination of the type of the genus as to further complicate the matter, I now formally propose the adoption of *M. ovata* (Conrad) as the genotype of Modiolopsis.

M. ovata belongs to the well-known group of *M. concentrica* H. and W. The group is best and most characteristically developed in the Richmond formations, but is well represented also in the Lorraine and Maysville groups, in the Eden and Trenton, and the Upper Black River. If the surface markings are disregarded the type is clearly recognizable even as early in geological history as the Lower Stones River. Basing our conception of the genus on this group as a whole, Modiolopsis may be redefined as follows:

MODIOLOPSIS Hall (emend. Ulrich)

Generic Diagnosis. Shells with a black epidermis, subovate, widest posteriorly, the dorsal edge very gently convex, the ventral side slightly sinuate. Umbones, though small and rather low, projecting distinctly above the hinge-line, situated near the anterior end and over the inner third of the deeply impressed anterior adductor scar; umbonal ridge rounded, low, notable mainly because of an undefined but wide depression over the antero-ventral slope; cardinal slope gently concave. Surface usually with concentric lines and narrow ribs, the latter strongest, rounded, and most regularly spaced on the posterior half. Hinge-plate thin, with a single, undefined subrostral tooth and socket in each valve; ligament external but lying partly in a very narrow area. Pallial line simple; posterior adductor scar large but very faintly outlined.

Genotype. Modiolopsis ovata (Conrad). Upper part of Pulaski shale, New York; Fairmount limestone of the Maysville group, Cincinnati, Ohio, and vicinity.

Stratigraphic Range. About twenty-five species, ranging from Lower Stones River to Medina and possibly Clinton.

So far as the generic relations of the described species have been verified the following fall under the genus as here restricted:

M. arguta Ulrich. Upper Black River, Minnesota
M. chatfieldensis Ulrich. Upper Black River, Minnesota
M. concentrica Hall and Whitfield. Richmond, Ohio
M. excellans Ulrich. Richmond, Minnesota
M. faberi Miller. Maysville, Ohio
M. meyeri Billings. Trenton, Ontario
M. mytiloides Hall. Trenton, New York
M. nana Ulrich. Trenton, Minnesota
M. obsoleta Ulrich. Upper Black River, Minnesota
M. ovata (Conrad). Pulaski, New York
M. oweni Ulrich. Trenton, Minnesota
M. postplicata Foerste. Pulaski, Quebec
M. rogersensis Foerste. Upper Trenton, Kentucky
M. similis Ulrich. Upper Black River, Minnesota
M. simulatrix Ulrich. Eden, Kentucky
M. valida Ulrich. Richmond, Ohio and Indiana
M. versaillesensis Miller. Richmond, Indiana
A number of undescribed species from the Richmond of Ohio and beds of Eden and Maysville age in the Ohio valley and New York.

The above diagnosis of *Modiolopsis* and the list of verified species do not include the newly named *M. halli* and its immediate allies. The number of these allied species is not great—only five or six—and all are unpublished. But some of them are very abundant fossils and, therefore, worthy of notice. The whole *Modiolopsis halli* group differs from typical

Modiolopsis in the extreme reduction of the umbo and umbonal ridge, in their relatively thick shells, and almost smooth surface. In all of these features the group resembles certain species now referred to *Modiolodon*. Possibly they also should go into that genus. On the other hand it might be better to view them together with their allies now under *Modiolodon* as constituting a separate genus or subgenus. However, the determination of this matter may well be left to such time when the publication of the concerned species shall have become possible.

Having fixed the genotype of *Modiolopsis* and redefined the genus the ground is cleared for any further restriction of the genus that may be required to satisfy the demands of convenience in reference and those of classification according to genetic alliances. On previous occasions I have already done much to break up the exceedingly heterogeneous assemblage of species that in the past seventy-five years of progress in palæozoic palæontology has accumulated by addition to the fourteen species originally referred to the genus by Hall. According to Bassler's catalogue one hundred and four species have been referred to Modiolopsis; and only thirty-four of these have been removed to other genera. Most of the latter were distributed among such more recently established genera as *Colpomya*, *Eurymya*, *Endodesma*, *Modiolodon*, *Prolobella*, *Whiteavesia*, and *Pholadomorpha*, the last being proposed by Foerste, the others by Ulrich. Doubtless more than half of the seventy species still retained in the genus in Bassler's catalogue will have to be removed to other genera when their types or, where necessary, better specimens, shall have been subjected to critical study and comparison. Some, even, can not belong to the same family. And some others will be shown to be synonyms, occasioned in most cases by misapprehensions as to the probable effects of rock compression in the resulting distortion of specimens.

On the present occasion only three of the species previously referred to *Modiolopsis* will be removed and placed in the proposed new genus *Modiodesma*. These are: (1) the typical *M.* (*Pterinea* and *Cypricardites*) *modiolaris* of Conrad 1838 and 1841 (including its named variety *Cypricardites angustifrons* Conrad, 1841); (2) *M. oblonga* Ulrich; and (3) *M. kentonensis*, Ulrich. With a single exception, *Modiodesma scapha* n.sp., figured on Plate XXXIII (figures 1, 2). The other species and varieties that will make up the bulk of the new genus *Modiodesma*, now known, must remain for the present unpublished.

MODIODESMA n. gen. Ulrich

Generic Diagnosis. More or less elongate modiolopsid shells, with the hinge nearly straight and the mesial depression and marginal sinus so little developed that the ventral edge remains more or less convexly curved throughout. Anterior fourth or third of surface with distinct, rounded, closely and regularly disposed concentric ribs. Posteriorly these die out or pass into more obscure and wider-spaced concentric growth lines and varices that commonly increase in strength again on the cardinal slope. Shell thin, umbones very moderately prominent, depressed convex, and passing diagonally backward into barely distinguishable umbonal ridges; beaks usually farther removed from the anterior extremity than in *Modio-*

lopsis. Cardinal slope of clean and sharply preserved casts of the interior nearly flat, with a varying number of radiating raised lines or bands. These converge toward the incurved beaks and outline the wide progressive track of the posterior adductor scar. Anterior adductor scars large, moderately to deeply impressed, vertically furrowed, situated entirely in front of the beaks. Hinge-plate very thin, edentulous, the valves held together by linear inner and outer ligaments, the former lying in a narrow channel partly defined on its inner side by a thin, longitudinal rib which leaves a corresponding slit-like depression on interior casts. The outer ligament extends to the posterior extremity of the hinge, seems longer than the inner, and differs from it in having a black epidermis.

Genotype. Modiodesma modiolare (Conrad) = *Modiolopsis modiolaris* Hall, part.,[1] fig. 1 *a* (typical), 1 *b* [var. *angustifrons* (Conrad) type of *Cypricardites angustifrons* Conrad], and 1 *d* (var. *brevior* n. var. Ulrich); not 1 *c* of same plate, which represents the form for which the new names *Modiolopsis halli* is proposed on a preceding page, or 1 *f*, which is from Madison, Ind., and probably belongs to the Upper Richmond species *Modiolopsis valida* Ulrich; or 1 *e*, which is the type of *M. ovata* (Conrad) and the genotype of Modiolopsis. *Modiodesma modiolare* var. *angustifrons* is refigured in the present report (Plate XXXII, figures 4, 5).

The Ulrich collection in the U. S. National Museum contains from one to fifty or more specimens of each of twelve or thirteen Upper Ordovician species that agree in all essential generic respects with the genotype of Modiodesma. Three of these, including *Modiolopsis oblonga* Ulrich and *Whiteavesia kentonensis* Ulrich, were found in the Cynthiana formation, which comprises the highest members of the Trenton group as developed in central Kentucky. Three more of the twelve were found in the middle or Southgate member of the overlying Eden shale. One of these Eden species occurs also in the Frankfort shale in New York. Of the remaining six or seven species five are represented by specimen found in the upper part of the Fairview limestone of the Maysville group, at and in the vicinity of Cincinnati, and also in corresponding zones of the Lorraine formation at Pulaski and other localities in New York. The other two occurred with the latter in drifted Lorraine slabs collected near Trenton Falls, New York. Of these, only the genotype and its two varieties—which, as noted above, were figured by Hall in 1847—and two of the *Cynthiana* species are published. One of the new Maysville and Lorraine species (*Modiodesma scapha*) is figured on Plate XXXIII (figures 1, 2) and its characters briefly noted in the accompanying legend.

Modiodesma agrees closely in nearly all respects with *Pholadomorpha*, Foerste, except that its shells lack the divaricating ribs which cross the fine concentric lines on the cardinal and ventral slopes and constitute the main characteristic of that genus. Considering other genera of the family *Modiodesma* may be said to occupy an intermediate position between typical Modiolopsis and Orthodesma on the one hand and Whiteavesia on the other, though perhaps nearer the latter than either of the former. In fact, on previous occasions[2] I have united this group with *Whiteavesia*. Now, however, especially since Foerste has proposed the new generic

[1] Pal. New York, vol. 1, p. 294, plate 81.
[2] Minn. Geol. Surv., vol. 3, pt. 2, p. 513, 1894; Ohio Geol. Surv., vol. 7, p. 656, 1893.

name Pholadomorpha for Hall's *Modiolopsis pholadiformis*, which also in 1893 I referred to *Whiteavesia*, the desirability of a more discriminating generic grouping of these fossil Pelecypoda is being more generally recognized.

The main differences between *Modiodesma* and *Whiteavesia*, as determined by comparison of specimens of a dozen or more species of each in the U. S. National Museum, are as follows: (1) in *Whiteavesia* the umbones are more prominent and larger and commonly form more definitely developed umbonal ridges than in *Modiodesma;* (2) the ligament was short and only external in *Whiteavesia*, whereas in *Modiodesma* it was not only longer but there was a ligament on the inner side of the hinge-line as well as on the outer side; (3) in *Whiteavesia* the shell is even thinner and the muscular scars, therefore, much less clearly impressed than in the new genus. As a rule, too, the shells of *Whiteavesia* exhibit more or less clear evidence of lines radiating from the beaks, in part probably indicating colour bands. No such lines have been observed on the exterior of any of the known species of *Modiodesma*. However, similar lines are occasionally visible on perfectly clean and sharp casts of the interior (Plate XXXIII, figure 3). In *Modiodesma*, on the contrary, the concentric surface markings usually are stronger and more regularly disposed on the anterior third than on the remainder of the surface, whereas in *Whiteavesia* the whole surface is uniformly and less regularly traversed by ordinary lines and undulations marking stages of growth.

In *Modiolopsis*, as here restricted and defined, the sides of the valves always show a broad and undefined depression in the antero-median quarter of the ventral slope, the ventral edge consequently is always more or less gently concave and the umbonal ridge, though rounded and never very prominent, is yet a more conspicuous feature than in *Modiodesma*. Further, the hinge-plate is relatively thick and commonly forms an obscurely defined cardinal tooth and socket in each valve. Besides, the ligament is external only. Finally, as a rule, the concentric surface markings in species of *Modiolopsis* tend to be stronger and more regularly disposed on the cardinal slope and the posterior half than on the narrower anterior half of the shell, which is directly the opposite of the condition usually obtaining in *Modiodesma*.

So far as hinge structure, impress of muscular scars, and in some cases also general aspect, are concerned, *Modiodesma* is as near *Orthodesma* as to any other Ordovician pelecypod. As a rule, however, the shells of the new genus are less elongate and their dorsal and ventral edges less nearly parallel than in the shells of the latter genus. Generally, also, there is no such striking difference in the character and regularity of the concentric surface markings on the two ends of the shells in *Orthodesma* as in *Modiodesma*. But the most important of the differences between the two genera is that in *Orthodesma* the valves gape slightly at the ends, whereas in *Modiodesma* they close tightly all around.

Modiodesma modiolare (Conrad)
Plate XXXII, Figures 1-3; Plate XXXIII, Figures 3-6; Plate XXXI, Figure 1

Cypricardites modiolaris Emmons, Nat. Hist. New York Geol. 2, 1842, p. 403, fig. 4.
Modiolopsis modiolaris Hall, Pal. New York, 1, 1847, p. 294, pl. 81, fig. 1 *a*.
Modiolopsis modiolaris Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 281, pl. 3, fig. 1; pl. 5, figs. 1, 2.

Ventral margin forming angle of 10 to 17 degrees with hinge-line; moderately convex or nearly straight, never incurved. Anterior margin and lower posterior margin rather rapidly rounded; posterior margin forming an angle of about 130 to 135 degrees with hinge-line, curving strongly toward front on approaching the latter. Valves relatively flat. Beaks low and closely appressed, located a considerable distance back from the anterior margin. Umbonal parts rather strongly flattened, but not depressed into a mesial sinus. Surface, with concentric striæ more distinctly developed anteriorly than along posterior margin.

Locality and Horizon. Originally described from the Pulaski member of the Lorraine formation, near Pulaski, New York. Specimen figured by Hall in the Paleontology of New York, on Plate 81, as figure 1 *a* is from the same horizon, Rome, New York.

Miss Stewart figures[1] a specimen of *Modiodesma*, from the Don brickyard, which closely resembles *Modiodesma modiolare*, but the preumbonal slope appears less flattened and the posterior margin of the shell rounds more gradually into the hinge-line.

Orthodesma (?) *postplicatum* Foerste
Plate XXIX, Figure 4

Modiolopsis postplicata Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 284, pl. 1, fig. 4.

Shell narrowly elongate. Hinge-line arcuate posterior to the beak, gently declining toward the posterior extremity, and gradually rounding into the posterior margin. Umbonal ridge broad and low posteriorly; rounded rather than angulate. Mesial depression undefined and shallow, forming a slightly concave outline anterior to the middle of the basal margin.

Cardinal or post-umbonal slope marked by regular, even, concentric plications, becoming obsolete toward the crest of the umbonal ridge. These plications mark former successive stages of growth of the posterior margin of the shell. There are about five plications in a length of 5 mm., increasing to six in the same length posteriorly. Within 10 mm. from the posterior margin, fine concentric striæ are present in addition to the plications. Concentric striations are present also on the areas below the umbonal ridge; these striations are faint posteriorly, but become more sharply defined anteriorly, where they also are more crowded.

[1] Twenty-ninth Ann. Rept. Ontario Dept. Mines, 1920, pt. 6, pl. III, fig. 1.

The valves probably were very thin, since not only the position of the anterior muscle scar, but also the location of the pallial line, for a length of 10 mm., are indicated distinctly. Both the cardinal and basal margins are curved, their curvature being subparallel.

Length 58 mm.; maximum height 18 mm.; height at beak 16 mm.; extension of shell anterior to beak about 10 mm.; convexity of single valve about 4 mm.

Originally described under *Modiolopsis*, but its very elongate outline suggests relationship to *Orthodesma*. Unfortunately it is impossible to determine from the specimen whether the ends of the specimen gaped, as in typical *Orthodesma*.

Locality and Horizon. Huron river, collected by Thomas Curry, in 1872, associated with *Lophospira beatrice* in the same slab. From the Pholadomorpha zone, possibly from the lower part of the Waynesville formation (No. 8424).

Orthodesma approximatum Foerste
Plate XXIX, Figure 5

Orthodesma approximatum Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 285, pl. 1, fig. 5.

Shell possibly closely related to *Modiolopsis postplicata*, but differing in the absence of conspicuous plications on the post-umbonal slopes. If this species is an *Orthodesma* it belongs to the *O. curvatum* group. Cardinal margin slightly curved posteriorly. Excepting near the beak, umbonal ridge distinguished only faintly from the general convexity of the shell, the mesial sulcus being nearly obsolete. Surface marked by faint concentric striations and wrinkles which are most distinct below and anterior to the beak. Along the post-umbonal slopes, when held in a very oblique light, may be seen very faint concentric wrinkles, about eight or nine in a length of 5 mm., but it is difficult to imagine these as suggesting identity of the form here described as *O. approximatum* with *Modiolopsis postplicata*. Position of anterior muscle scar and of adjacent part of the pallial line distinctly indicated for about 10 mm. General appearance of the shell smooth. From the cardinal side of the umbonal ridge, near the beak, a low angulation extends backward, gradually deviating from the cardinal margin, until at a distance of 30 mm. from the beak it is fully 2·5 mm. from this margin. Above this angulation the surface along the cardinal margin is concave, as though the cardinal parts of the two valves had been more or less appressed posteriorly.

Length about 50 mm., greatest height 19 mm., height at beak 17 mm., extension of shell anterior to beak 8 or 9 mm., convexity of the single valve about 5 mm.

Locality and Horizon. Richelieu river, at Chambly, collected in 1881 by A. H. Foord. Associated with *Glossograptus quadrimucronatus approximatus*. In the *Proetus* zone, Lorraine (No. 8425).

Under the name *O. approximatum*, Miss Stewart figures from the Humber River region a new species with a strongly defined umbonal ridge abruptly limited anteriorly by a broad mesial sinus which straightens the ventral margin or even gives it a slightly concave course. Ventral and posterior cardinal margins nearly straight, diverging from each other but slightly posteriorly. Anterior to the beaks, the anterior part of the shell extends forward one-fourth the length, the upper margin of this part being approximately horizontal, but on a level about 2 mm. lower than the posterior part of the hinge-line.[1]

Orthodesma canaliculatum Ulrich
Plate XXV, Figure 4 *a*, *b*

Orthodesma canaliculatum Ulrich, Geol. Minnesota, 3, pt. 2, 1894, p. 520, pl. 37, figs. 7-11.

Height nearly one-third of length. Cardinal and ventral margins parallel, except anterior to the beak where the hinge-line is at a much lower level, the anterior part of the shell being prolonged and narrowly rounded. Valves in contact dorsally and ventrally, but not at the anterior and posterior ends, which gape distinctly. Umbonal ridge distinct along its entire length. A broad mesial sinus flattens the anterior slope of the umbones and extends obliquely downward and backward, causing the ventral margin to be slightly concave. Along hinge-line dorsal margins of shell infolded, producing a channel-like depression. Pallial line extends from the lower posterior margin of the anterior muscle impression diagonally downward to a point immediately posterior to the termination of the mesial sinus.

Locality and Horizon. Originally described from the Waynesville, southwestern Ohio, but identified also from Indiana and Spring Valley, Minnesota.

A similar form occurs in the Waynesville member, Snake island.

Orthodesma canaliculatum consimilis var. nov.
Plate XXIII, Figure 8

Specimen evidently related to *Orthodesma canaliculatum* Ulrich, from the Waynesville. As in that species, the pallial line starts at the posterior end of the base of the anterior muscle scar and passes in a straight line to the posterior end of the ventral outline of the valve. Almost imperceptible radiating folds cross this line in about the same direction as those figured in the Waynesville species. General outline about the same. However, in the Meaford specimen, here described, height relatively greater, being 17 mm., length 44 mm., giving a ratio of 39 per cent, as contrasted with a ratio of 32 per cent in typical *O. canaliculatum.* Umbonal ridge less strongly defined, and the mesial sinus almost obsolete. The anterior part of the shell projects a shorter distance from the beak, upper anterior slope correspondingly more oblique. Substance of the shell black in colour, and nearly a millimetre thick below the anterior muscle scar.

Locality and Horizon. Workman brook, 13 feet below the lowest specimens of *Catazyga* in this locality. This *Catazyga,* resembling *C. erratica,* occurs 51 feet above the base of strata provisionally referred to the Lorraine (No. 8455).

[1] "Stratigraphy and Paleontology of Toronto and Vicinity"; 1920, pl. 5, fig. 1.

Orthodesma prolatum Foerste
Plate XXIX, Figure 15

Orthodesma prolatum Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 289, pl. 1, fig. 15.

Hinge-line posterior to the beak apparently straight, meeting the upper part of the oblique posterior margin at an angle of about 120 degrees. Umbonal ridge rather angular, especially toward the beak. Post-umbonal slope, between ridge and cardinal margin, flattened, or, rather; consisting of two flattened areas meeting each other at an angle of about 170 degrees. At the posterior extremity of the shell, this second line of angulation is about 5 or 6 mm. distant from the crest of the umbonal ridge and 4 mm. distant from the cardinal margin. It is not known whether this second line of angulation is a constant characteristic of the species, but, in the single individual at hand, the concentric striæ become conspicuously more prominent, broader, and more regular, between this second line of angulation and the cardinal margin, than elsewhere on the shell. Along the cardinal margin about eight striæ in a length of 5 mm. Elsewhere on the shell the concentric striæ are finer and closer, and accompanied by obscure concentric undulations of growth. Although the anterior margin is not preserved, enough of the shell anterior to the beak is seen to indicate that the concentric striæ and obscure undulations are not gathered up anteriorly into a series of strong concentric folds, as in *Rhytimya*, nor are there any obliquely radiating series of granules between the umbonal ridge and the basal margin as in characteristic species of that genus, to which the present form evidently is not related.

Cardinal and basal margins subparallel posterior to the beak, height being 11·5 mm. at the beak and 13 mm. at the posterior end. The defective anterior end indicates a projection of about 11 mm. Length 38 mm., convexity of the single valve about 4 mm.

Locality and Horizon. Collected loose on the beach below Bécancour river, by James Richardson, in 1852. In the same slab are numerous fragments of a *Strophomena* resembling *Strophomena hecuba* (No. 2144). From the Waynesville.

Orthodesma pulaskiense Foerste
Plate XXXI, Figure 6

Orthodesma pulaskiensis Foerste, Bull. Denison Univ., 17, 1914, p. 288, pl. 3, fig. 6.

Shell about three times as long as high, enlarging slightly from the beaks toward the posterior end, abruptly narrowed anterior to the beaks. Posterior end obliquely truncated. Umbonal ridge fairly angular near the beaks, diverging at a small angle from the hinge-line along the anterior half of its course, amount of divergence increasing along posterior half. The pallial line starts at the lower posterior end of the anterior muscle impression and inclines diagonally downward toward that part of the ventral margin posterior to the mesial sinus. The latter flattens the pre-umbonal slope and causes a slight depression a short distance posterior to the beaks, producing a faint concavity of outline along the ventral margin.

Locality and Horizon. Described from the Pulaski formation at the railway bridge 1 mile east of Pulaski, New York.

A form with somewhat similar outline, but with the beak nearer the anterior margin, was found in the upper part of the Pulaski member of the Lorraine, in the fossiliferous sandstones at the crossroads, one mile south of Barnes Corners (Plate XXXI, figure 11). Umbonal ridge not angular, and distinct only near the beak. Body of the shell more convex, rounding more evenly into the post-umbonal slope. General aspect that of a *Cymatonota,* but with no oblique wrinkles along the hinge-line.

Orthodesma nasutum (Conrad)

Plate XXXI, Figure 5 *a, b;* Plate XXXVIII, figure 9

Modiolopsis nasutus Hall, Pal. New York, 1, 1847, p. 296, pl. 81, fig. 2.
Orthodesma nasutum Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 286, pl. 3, fig. 5; pl. 5, fig. 3.

Outline oblong dorsal and ventral margins subparallel, rapidly rounded, and abruptly narrowed anterior to the beaks, in a direction at right angles to the length, anterior portion of hinge-line much lower than posterior. Upper part of the posterior margin broadly and obliquely curved, rounding evenly into the posterior end of the hinge-line.

Locality and Horizon. Originally described from the Pulaski formation, Lorraine, New York.

Also identified from the *Pholadomorpha* zone of the Lorraine, Weston. Miss Stewart figures from 10-foot level in the Humbervale quarry a specimen which resembles the type of the species more closely than any other known specimen.[1]

Psiloconcha inornata Ulrich

Plate XXV, Figure 5

Psiloconcha inornata Ulrich, Geol. Surv., Ohio, 7, 1893, p. 667, pl. 52, figs. 11, 12.

Outline elliptical, ventral margin almost straight. Beaks very small. Umbonal ridge scarcely distinguishable.

Locality and Horizon. Originally described from the Bellevue member of the Maysville, Cincinnati, Ohio. Identified also from the *Pholadomorpha* zone, Lorraine, at St. Hilaire.

Figured from the 15-foot level in the Humbervale quarry at Toronto, by Miss Stewart.[2]

Psiloconcha subovalis Ulrich

Plate XXV, Figure 7; Plate XXX, Figure 15 *a, b*

Psiloconcha subovalis Ulrich, Geol. Surv., Ohio, 7, 1893, p. 666, pl. 52, figs. 5-7.
Psiloconcha subovalis Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 295, pl. 2, fig. 15.

Outline elliptical lengthwise, ventral margin curving evenly into anterior margin, latter rounding rapidly into hinge-line. Hinge-line

[1] "Stratigraphy and Paleontology of Toronto," 1920, pl. 5, fig. 3.
[2] "Stratigraphy and Paleontology of Toronto and Vicinity," 1920, pl. 5, fig. 11.

straight. Length about twice height. Beaks very inconspicuous and located about one-sixth of the length of the shell from the anterior margin. Umbonal ridge fairly distinct though not at all conspicuous.

Locality and Horizon. Originally described from the Bellevue member of the Maysville, Morrow, Ohio (No. 8408).

Similar forms occur in the Waynesville, St. Hilaire, and in those strata at Huron river which belong either to the *Pholadomorpha* zone of Lorraine, or to the overlying part of the Waynesville. They may belong to a different species.

P. subovalis is figured by Miss Stewart from the Don brick-yard.[1] The specimen figured from the 10-foot level at the Humbervale quarry, Toronto,[2] also probably belongs to *P. subovalis* rather than to *P. sub-erecta*, the latter being a narrower species, ventral and cardinal sides straighter for a longer distance, the height being about two-fifths of the length.

Psiloconcha sinuata Ulrich

Plate XXV, Figure 6

Psiloconcha sinuata Ulrich, Geol. Surv., Ohio, 7, 1893, p. 668, pl. 52, figs. 15, 16.

Outline elliptical; length almost three times the height. Mesial sinus sufficiently distinct to produce a slightly concave outline along almost the entire length of the ventral margin; umbonal ridge relatively distinct. Hinge-line about straight.

Locality and Horizon. Originally described from the Bellevue member of the Maysville, Cincinnati, Ohio.

Forms similar in outline occur also in the Lorraine of *Proetus* zone near Vars, in the *Pholadomorpha* zone in the Nicolet River section, and at St. Hilaire.

Psiloconcha sinuata borealis Foerste

Plate XXX, Figure 9 *a, b, c;* Figure 10

Psiloconcha sinuata borealis Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 296, pl. 2, figs. 9 A-C.

Specimen about 22 mm. in length, with the hinge-line straight for a distance of about 7 mm. posterior to the beak, then deflected downward at an angle of about 165 degrees for a distance of about 8 mm. before curving rapidly into the rather narrowly rounded posterior margin. Umbonal ridge and mesial sulcus very oblique, and only moderately distinct, but more so than in most species of this genus. Umbonal ridge most defined within about 5 mm. of the beak. Below this part of the ridge shell flattened, becoming more concave on following the mesial sulcus. Basal margin comparatively straight, but in older specimens easily might become slightly concave. The chief difference between the form here figured and typical *P. sinuata* Ulrich consists in the anterior outline, which is less quadrate, the hinge-line anterior to the beak being less in line with that posterior to the same, but rather deflected downward as in *P. inornata* Ulrich. Convexity of the single valve fully 2 mm.

1 "Stratigraphy and Paleontology of Toronto and Vicinity," 1920, pl. 5, fig. 10.
2 Loc. cit. fig. 5.

Locality and Horizon. Huron river (Nos. 2087, 8411), collected in 1872 by Thomas Curry, in the *Pholadomorpha* zone, Lorraine, or in the lower part of the Waynesville. At the same horizon also in the Nicolet River section.

Miss Stewart figures from the Don brick-yard a specimen which differs from the type of the variety only in being slightly taller. It comes from a much lower horizon.[1]

Pholadomorpha pholadiformis (Hall)
Plate XXX, Figure 16

Modiolopsis pholadiformis Hall, Geol. Lake Superior Land Dist., Foster and Whitney's Rept., 1851, p. 213, pl. 30, figs. 1 *a-c;* pl. 31, fig. 1.
Whiteavesia pholadiformis Ulrich, Geol. Surv., Ohio, 7, 1893, pl. 56, figs. 21, 22.
Pholadomorpha pholadiformis Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 277, pl. 2, fig. 16; pl. 5, fig. 4.

Outline longitudinally oblong ovate, ventral margin diverging from the hinge-line at a moderate angle, varying around 15 degrees. Beak broad, projecting but slightly above hinge-line. Anterior to the beak, the upper margin rises to the same height as the hinge-line posterior to the same. The anterior margin extends about one-fifth of the length of the shell in front of the beak, rounding into anterior part of the hinge-line with only a moderate increase in its convexity. General surface of the shell comparatively flat, umbonal ridge being weakly defined, except near the beak. Slope beneath the umbonal ridge more or less vertically plicated. Above the umbonal ridge, especially toward the upper posterior margin, the plications tend to be directed diagonally backward and upward.

P. divaricata Hall and Whitfield (Plate XXX, figure 14) appears merely to have been founded upon a form in which the plications are unusually distinct, on the post-umbonal slope as well as on the body of the shell.

Locality and Horizon. Originally described from the lower part of the Richmond on the eastern shore of Little Bay de Noquette, east of Escanaba, Michigan, in strata comparable with the Waynesville member.

Known from the Waynesville, also, in Ohio and Indiana.

It is widely distributed in Canada in the lower Waynesville occurring on Snake island, at Huron river, in the Nicolet River section, at Vars, and Streetsville.

In the *Pholadomorpha* zone, immediately below the strata definitely recognized as Waynesville, it occurs in the Nicolet River section, at St. Hilaire, Weston, Streetsville, southeast and northwest of Meaford, south of Clay cliffs, at various localities south of Little Current, and at Gorrel point northeast of Gore Bay (No. 8416).

In the Pulaski member of the Lorraine it occurs at Bennett bridge and at Salmon River falls, New York, associated with a form identified by Ulrich as *Ischyrodonta unionoides*, a characteristic Pulaski species.

[1] "Stratigraphy and Paleontology of Toronto and Vicinity," 1920, pl. 5, fig. 7.

Pholadomorpha chambliensis Foerste
Plate XXIX, Figure 8

Pholadomorpha chambliensis Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 281, pl. 1, fig. 8.

Shell longitudinally oblong, cardinal and basal margins diverging scarcely 10 degrees. Anterior margin more broadly rounded and posterior margin less oblique than in typical *P. pholadiformis*. The low, transverse plications can be detected only on the posterior half of the shell, on the slope beneath the umbonal ridge, but they may be more distinctly indicated on other individuals. Umbonal ridge angulate along its upper outline for a distance of about 15 mm. from the beak, rounding rapidly posteriorly, merging into the general convexity of the shell.

Length 68 mm., height posteriorly 28 mm., height at beak 24 mm., extension of shell anterior to beak about 12 mm., convexity of the single valve about 3 mm.

Locality and Horizon. Apparently from Chambly, from a siliceous limestone containing also *Catazyga headi*, *Rafinesquina alternata*, and *Byssonychia radiata*. Supposed to be from the *Proetus* zone, Lorraine (No. 2069).

Rhytimya compressa Ulrich
Plate XXV, Figure 12

Rhytimya compressa Ulrich, Geol. Surv., Ohio, 7, 1893, p. 692, pl. 56, fig. 13.

Valves of very little convexity, preumbonal slopes flattened, without a mesial sulcus, ventral outline gently convex. Anterior part of hinge-line only slightly below the level of posterior portion. The posterior of the valve relatively tall. Granules exceedingly small, radiating lines formed by them just visible to the unassisted eye.

Locality and Horizon. Originally described from the Fairmount member of the Maysville, Cincinnati, Ohio.

In the *Proetus* zone, Lorraine, at Chambly Canton, specimens of *Rhytimya* occur which resemble *R. compressa* in outline, but which have sharply-defined postumbonal radiating striæ. They evidently can not belong to the same species.

Miss Stewart figures from the lower 8 feet of the Don brick-yard a form closely resembling *R. compressa* in outline.[1]

Rhytimya colemani Stewart
Plate XXII, Figure 11

Rhytimya colemani Stewart, 29th Ann. Rept. Ontario Dept. Mines, pt. 6, 1920, p. 46, pl. 5, fig. 13.

Right valve with the anterior margin and the lower posterior margin missing, restored in the accompanying figure in accordance with the course of the concentric markings. There is a broad but distinct mesial sulcus, the lower part of which is directed slightly to the rear of a strictly perpendicular line. Height of valve here 5·8 mm., increasing posteriorly

[1] "Stratigraphy and Paleontology of Toronto and Vicinity," 1920, pl. 5, fig. 14.

to 6·5 mm. or possibly slightly more. Length of valve estimated at 18 mm. Concentric wrinkles strongly defined along body of the valve, and even more strongly anteriorly, but along the umbonal ridge and posterior to it they are relatively weak. Umbonal ridge distinct toward the beak, but merges into the general convexity of the shell posteriorly. Weakly defined radiating rows of minute granules traverse the body of the shell. At one point posterior to the sulcus and slightly above mid-height an horizontal row of seven granules in a length of 2 mm. can be detected readily. Those below this level can be detected by coating with ammonium chloride and using cross-illumination.

Among described species, the specimen most nearly resembles *R. œhana*, from the upper or McMillan division of the Maysville, but it is more elongate and the mesial sinus is less oblique.

Locality and Horizon. From the Don brick-yard (No. 1031, Royal Ontario Museum).

Rhytimya œhana Ulrich

Plate XXV, Figure 13; Plate XXIX, Figure 11

Rhytimya œhana Ulrich, Geol. Surv., Ohio, 7, 1893, p. 689, pl. 56, fig. 1.
Rhytimya œhana Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 307, pl. 1, fig. 11.

Shell relatively large, cardinal and ventral margins parallel, mesial sulcus distinct, ventral margin slightly concave. Umbonal ridge distinct as far as the lower posterior angle of the shell, where the outline is narrowly rounded. Posterior outline of the shell only moderately curved, forming an angle of about 125 degrees with the hinge-line. Anterior part of the hinge-line concave and inclined downward at an angle of about 30 degrees below the horizontal, the upper anterior angle being rather abruptly rounded.

Miss Stewart figures from the lower 8 feet of the Don brick-yard, a form closely resembling *R. œhana* in outline.[1]

Locality and Horizon. Originally described from the McMillan division of the Maysville, Cincinnati, Ohio.

A similar form was found in the *Proetus* zone of the Lorraine formation, Chambly Canton (No. 8423).

Rhytimya radiata Ulrich

Plate XXV, Figure 14

Rhytimya radiata Ulrich, Geol. Surv., Ohio, 7, 1893, p. 688, pl. 56, figs. 6-9.

Compared with *Rhytimya compressa*, this species is smaller, more convex, straighter along the middle of the ventral margin, narrower posteriorly, with a very faint mesial sulcus. Radiating lines of granules much more distinct.

Locality and Horizon. Originally described from the middle or Southgate member of the Eden, Cincinnati, Ohio.

Similar specimens occur in the *Pholadomorpha* zone of the Lorraine half a mile south of St. Hilaire station.

[1] "Stratigraphy and Paleontology of Toronto and Vicinity," 1920, pl. 5, fig. 15.

Rhytimya granulosa Wilson
Plate XXXVIII, Figure 2

Rhytimya granulosa Wilson, Ottawa Naturalist, 29, 1915, p. 85, pl. 2, figs. 1, 2.

Outline similar to that of *Rhytimya radiata* Ulrich, except along the ventral margin where the outline is gently concave, owing to the distinct mesial sulcus. Radiating striæ distinct everywhere except near the beak and anterior to the mesial sulcus, relatively crowded on the post-umbonal slope, where the granules are connected quincuncially by a microscopic series of fine lines.

Miss Stewart figures from the 6-foot level at the Don brick-yard, a small specimen, showing on the post-umbonal slope the net-work of lines described by Miss Wilson in the type of *R. granulosa.*[1]

Locality and Horizon. Described from the *Proetus* zone of the Lorraine formation near Vars.

Rhytimya kagawongensis Foerste
Plate XVI, Figure 10 *a, b*

Rhytimya kagawongensis Foerste, Bull. Denison Univ., 17, 1914, p. 482, pl. 4, fig. 5.

Valve evenly and comparatively strongly convex; umbonal ridge only slightly defined toward the beak, merging into the general convexity of the shell posteriorly. Toward the dorsal side of the umbonal ridge the rapidity of curvature is increased, and within a short distance of the dorsal margin there is, in some specimens, a narrow groove which gradually diverges from this margin, and at its posterior end is about 1 mm. distant from the latter. Anterior outline rather evenly convex, and not angulate toward the top, as in most species of *Rhytimya.* Mesial sinus usually obsolete. Ventral margin of the shell gently convex. Occasionally a very faint mesial sinus is present, and then the ventral margin is comparatively straight along the region traversed by the sinus. Most valves narrow distinctly posteriorly. In one specimen, 18 mm. long and 9·5 mm. high at the beak, 4 mm. from the posterior end of the valves the height is only 6 mm. The anterior outline extends about 4 mm. in front of the beak.

Radiating lines of discrete granules traverse the posterior and ventral parts of the shell, but are not noticed on the post-umbonal slopes. Along the posterior part of the umbonal ridge they are about half a millimetre apart, so that seven occupy a length of 3 mm. Anteriorly, the radiating lines become more closely crowded, and in another specimen they number at least twelve directly opposite the beak. Lines more prominent and the granules larger toward the posterior end of the shell. Here they may become so crowded radially as to be slightly longer in a direction transverse to the length of the radiating lines than in a direction parallel to the latter. About six granules occupy a length of one millimetre along this part of the shell. Many of the concentric lines are indistinct over the central and umbonal parts of the shell, but are more distinct along

[1] "Stratigraphy and Paleontology of Toronto and Vicinity," 1920, pl. 5, fig. 12.

the margin and on the post-umbonal slopes; they do not increase in strength anteriorly so as to form folds. On the post-umbonal slopes they form an angle of 65 degrees with the dorsal margin.

Hinge-area very narrow, apparently without teeth. A very narrow groove extends between this area and the beak, and thence posteriorly. This may have served as the line of attachment for some external ligament. No lunule noticed.

Locality and Horizon. The type specimens were obtained in the silicified limestone exposed along the roadside, 1·5 miles southwest of Kagawong, on the road to Gore Bay (No. 8449).

Numerous specimens occur also along the roadside south of Kagawong, about a quarter of a mile beyond Kagawong Falls (No. 8536).

Three miles southwest of Little Current, along the east and west road.

Two miles southeast of Manitowaning, on the road to James bay.

All of these specimens occur above the *Stromatocerium* reef, in the Kagawong. A few specimens at Clay cliffs show that this upper horizon is present at the top of the section there also.

Meaford Specimens. About 6 miles northwest of Meaford, in the fossiliferous horizons in the Queenston red clay shales occur specimens having the form and outline of *R. kagawongensis*, but the surface is too weathered to show the radiating lines of granules, and in their absence the specific identity of these specimens can not be definitely established.

Conocardium richmondense Foerste

Conocardium richmondense Foerste, Bull. Sci. Lab. Denison Univ., 16, 1910, p. 71, pl. 2, figs. 21 A, B.

Conocardium is represented by *Conocardium beecheri* Raymond, in the Chazyan of northeastern New York, and on Mingan islands, eastern Canada. In the Leray member of the Black River formation it is represented by *Conocardium immaturum* Billings, from Paquette rapids, on Ottawa river, in Canada. It recurs in the Richmond formation, being represented by *Conocardium antiquum* (Owen) at Lower Fort Garry, on Red river, Manitoba; by *Conocardium richmondense* Foerste, near Richmond, Indiana; and by *Conocardium elegantulum* Billings in the Jupiter River and Chicotte formations of the Silurian on Anticosti island.

More recent studies have shown that Ordovician forms of *Conocardium* are represented by separate valves, as in true pelecypods, and that these Ordovician forms are not to be separated generically from the Silurian and Devonian species of Conocardium, whose pelecypod character has never been doubted.

Archinacella richmondensis Ulrich

Plate XXXIV, Figure 1 *a*, *b*

Archinacella richmondensis Ulrich, Geol. Minnesota, 3, pt. 2, 1897, p. 834, pl. 61, figs. 6, 7.

Shell patelliform, elliptical, with rather distant concentric lines of growth. Form that of a low cone with its apical end curving strongly forward, and located about one-sixth of the length of the shell behind its anterior margin. Highest point of shell a little less than one-third of its length from the anterior margin.

Archinacella indianensis (Miller) is figured as shorter, relatively narrower anteriorly, and broader posteriorly. From the Whitewater member of the Richmond formation, Fayette county, Indiana.

Locality and Horizon. Richmond, Indiana, in the Whitewater member of the Richmond formation.

Archinacella kagawongensis sp. nov.

Plate XXXV, Figure 2 *a, b, c, d*

Specimens similar to *Archinacella richmondensis* Ulrich; one specimen being 20 mm. long, 16 mm. wide, and 7 mm. high, with the apex only a small distance behind the anterior margin, maximum elevation of the dorsal profile about one-third of length of shell from its anterior margin. Concentric lines of growth present, but conspicuous only near the margins. Compared with *Archinacella richmondensis* the anterior part of the dorsal profile curves downward farther, bringing the apex to a relatively lower position.

All specimens found so far appear somewhat smaller and less distinctly striated concentrically than in typical *Archinacella richmondensis*.

Locality and Horizon. No. 8461, 2 miles southwest of Kagawong along the road to Gore Bay, in siliceous limestones 50 feet below the base of the Cataract limestone and 5 feet above the *Stromatocerium* horizon. Also about a mile south of Kagawong, along the road east of Kagawong lake.

No. 8462, near the top of the hill 2 miles southwest of Wekwemikong. No. 8563, at Clay cliffs. The first three specimens occurred in the Kagawong, but the last apparently came from the Meaford.

Archinacella lævis sp. nov.

Plate XXXV, Figure 3 *a, b, c, d*

Similar to *Archinacella richmondensis*, but differing in the following particulars: dorsal outline, between apex and posterior margin, more strongly curved, so that, although greatest elevation is about a third of the length of the shell behind anterior margin, apex is at a level 3 or 4 mm. below this highest point and projects farther toward the front, anterior profile being steeper. There is a faint increase of transverse curvature along the median line of the dorsal part of the shell, too faint to suggest a median ridge. Although the surface seems well preserved, no concentric lines of growth are present.

Locality and Horizon. Southeast shore of Snake island, in the Richmond (No. 8460 *a, b*).

Archinacella pulaskiensis Foerste

Plate XXXI, Figure 3 *a, b;* Plate XXIX, Figure 1

Archinacella pulaskiensis Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 309, pl. 3, figs. 3 A-B.

The form figured by Hall from the Lorraine at Pulaski, New York, under the name *Archinacella patelliformis*, differs in outline from his types, which were obtained from the Trenton limestone at Middleville, New York. This shell is broader and more convex along the middle, resulting in a broadly ovate, rather than oblong ovate, outline. In other respects the two forms are closely similar. Beak extends almost as far forward as anterior margin. Anterior profile, on lateral view, not strongly concave. Beak rather pointed, especially when viewed from above, and there is a tendency toward carination for a moderate distance posterior to the beak. Highest part of the shell about five-twelfths of the length from anterior margin. Surface smooth, surface striæ being faint or absent.

Locality and Horizon. The type of this species occurs at the *Cryptolithus* horizon, several hundred yards west of the railway bridge across the river, east of Pulaski, New York, in the Pulaski formation.

In Quebec it occurs in the Lorraine at the *Cryptolithus* zone, St. Hugues and St. Hyacinthe; in the *Proetus* zone at Chambly Canton and in the Nicolet River section.

Vallatotheca manitoulinensis Foerste

Plate XXXV, Figure 1 *a, b, c*

Vallatotheca manitoulini Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 482, pl. 4, fig. 4.

Dorsal outline of the shell strongly curved convexly, apex projecting beyond anterior margin about 5 mm. Maximum height at mid-length, about 10 mm., total length, as far as the apex, being 22 mm. At its tip, the apex is scarcely 2 mm. above the plane passing through the base of the shell. Surface marked by concentric laminæ, which become more distant from each other at later stages of growth, numbering six or seven in a length of 5 mm. in the more marginal parts of the specimen at hand. Free edges of laminæ diverge almost at right angles from the surface. Apical sides of the laminæ crossed by short striæ in a radiating direction.

Compared with *Vallatotheca ungiformis* Ulrich, from the Faulconer division of the Perryville member of the Trenton in central Kentucky, this species is larger and the beak is more strongly curved.

Locality and Horizon. Clay cliffs, in the Meaford (No. 8448).

Cyrtolites ornatus Conrad

Plate XXXIV, Figure 3

Cyrtolites ornatus Ulrich and Scofield, Geol. Minnesota, 3, pt. 2, 1897, p. 860, pl. 62, figs. 27-29.

Shell distinctly carinated along the dorsum and very angular along the middle of the lateral sides. Intervening areas strongly plicated and striated transversely, neither plications nor transverse striæ curving conspicuously backward on approaching the dorsum.

Specimens from the Waynesville on Snake island, and from the *Pholadomorpha* zone at St. Hilaire, have rather faint, short, oblique lines, at right angles to the transverse striæ.

Locality and Horizon. Originally described from the Pulaski member of the Lorraine formation in New York. Widely distributed in the Maysville and Richmond formations from Canada, and New York to Alabama, from Ohio to southern Tennessee, and elsewhere.

On Manitoulin island, a typical example (No. 8467), 25 mm. in diameter, was found at Clay cliffs, in the Meaford. Specimens occur also in the Lorraine in the *Pholadomorpha* zone south of Clay cliffs, and at McLean hill, 3 miles south of Little Current. At Weston, Ontario, it occurs in the *Pholadomorpha* zone. In Quebec, it is known in the Waynesville on Snake island and in the Nicolet River section. At St. Hilaire it occurs in the Lorraine in the *Pholadomorpha* zone, and at St. Hugues, in the *Cryptolithus* zone.

Cyrtolites subplanus Ulrich
Plate XXXIV, Figure 5

Cyrtolites subplanus Ulrich, Geol. Minnesota, 3, pt. 2, 1897, p. 846, pl. 62, figs. 40-44.

Shell angular along the back, but not conspicuously carinated; angular also along the middle of the lateral sides, resulting in subquadrate cross-sections of the volutions, line of contact between successive volutions being narrow. Profile of the slopes between the dorsum and the angulations of the lateral sides flat rather than conspicuously concave. Transverse striæ well defined. Short, oblique lines, at right angles to these striæ, inconspicuous. No well-marked transverse plications on the dorsal halves of the lateral sides.

Locality and Horizon. Nashville, Tennessee, in the Catheys member of the Trenton.

At St. Hyacinthe, a specimen of *Cyrtolites* was found at the extreme eastern end of the exposures in the river bed, upstream from the railway bridge. It has no transverse plications, and resembles *C. subplanus* in its general appearance. It was associated with *Cryptolithus bellulus*, and a short distance farther upstream similar rock contains *Triarthrus eatoni* and *Leptæna moniquensis*.

Cyrtolites parvus Ulrich
Plate XXXIV, Figure 4 *a, b*

Cyrtolites parvus Ulrich, Geol. Minnesota, 3, pt. 2, 1897, p. 864, pl. 62, figs. 45-47.

Shell small, angular dorsum, but dorsal keel not prominent. Middle of the lateral sides rounded rather than sharply angular, and the areas between middle parts of the lateral sides and the dorsum gently convex.

Locality and Horizon. Covington, Kentucky, in the Cynthiana formation.

Specimens somewhat resembling this species were found a short distance below the dam, in the river bed at St. Hyacinthe, in the *Cryptolithus* zone of the Lorraine.

Cyrtolites carinatus Miller

Plate XXXIV, Figure 2 *a, b, c;* Plate XXXV, Figure 5 *a, b*

Cyrtolites carinatus Ulrich and Scofield, Geol. Minnesota, 3, pt. 2, 1897, p. 862, pl. 62, figs. 50-52.

Shell relatively small. Strongly carinated both along the dorsum and along the middle of the lateral sides, intermediate areas being strongly concave on earlier part of the shell, but nearly flat along the latter half of the last volution. No transverse plications.

Locality and Horizon. Cincinnati, Ohio, in the middle or Southgate member of the Eden formation.

A small specimen, 11 mm. in diameter, having a rapidly expanding body whorl, and sharp dorsal and lateral carinæ, occurs in the Sheguiandah, at the top of the hill 3 miles southeast of Little Current, on the eastern road to Sheguiandah (No. 8468).

A similar specimen, with the body whorl expanding less rapidly, but with the characteristic sharp dorsal and lateral carinæ, was found in the Sheguiandah formation 2·5 miles north of Wekwemikongsing, about a quarter of a mile south of Clay cliffs.

Sinuites cancellatus (Hall)

Plate XXXIV, Figure 6 *a, b*

Protowarthia cancellata Ulrich and Scofield, Geol. Minnesota, 3, pt. 2, 1897, p. 872, pl. 63, figs. 1-14.

Aperture without an abruptly expanding flaring flange; dorsum rounded, not carinated, without a slit-band; umbilicus closed; surface markings rather obscure and not likely to attract attention.

Locality and Horizon. Originally described from Lorraine, New York, from the Pulaski member of the Lorraine formation. Widely distributed from the Trenton to the Richmond in Canada and New York; throughout the middle United States, chiefly in the Trenton.

Typical specimens, 20 to 25 mm. in diameter, occur in the Sheguiandah at Tamarack point, north of Honora, and at the same horizon 3 miles south of Little Current, at the top of the hill on the eastern road to Sheguiandah.

In Quebec, it occurs in the Lorraine, throughout both the *Leptæna* and *Proetus* zones in the Nicolet River section. In the *Proetus* zone it occurs also at Chambly Canton. In the Waynesville zone it occurs in those fragments thrown out by the waves on the southeastern shore of Snake island.

Oxydiscus perstriatus sp. nov.

Plate XXXVIII, Figure 5

Shell exposes three volutions, leaving room at centre for at least part of a fourth volution. Maximum diameter across the shell only 14 mm.

At larger end of last volution, where specimen is broken, lateral diameter of volution 6 mm. and vertical diameter 6·5 mm. In a cross-section, lateral sides converge gently from the umbilicus a little more than half-way to the carinated dorsum; here the lateral diameter is about 4 mm.; above this point rate of convergence more rapid until within 1 mm. from the dorsum, where lateral diameter is about 1 mm.; here the lateral outline becomes concave as far as the dorsum. Width of dorsum one-fourth of a millimetre; it is channelled lengthwise and bordered on each side by a narrow raised line, evidently indicating a slit-band. Along the margin of the umbilicus the shell curves rapidly and almost angularly inward and upward for a height of at least 1 mm., embracing the dorsum of the preceding volution along its median line. Surface marked by relatively strong striæ, which are equidistant, and which number about seven in a length of 2 mm. along the shoulder of the volution, about half-way between umbilicus and the dorsum. The transverse striæ curve strongly backward from the umbilicus toward the dorsum, rate of curvature being slightly accentuated at the shoulder just mentioned. In addition to the stronger striæ there are very much finer ones, scarcely visible under a lens.

This species is characterized by its relatively prominent and equidistant transverse striæ, and the strong upward curvature of the shell at the margin of the umbilicus.

Locality and Horizon. From Clay cliffs in the northern part of lake Huron. In the Richmond.

Among the Richmond material at the southeast end of Snake island, a small specimen of *Oxydiscus* was found similar in having equally coarse and distant transverse striæ, but the curvature at the margin of the umbilicus cannot be determined.

In *Oxydiscus magnus*, from the Richmond formation, Richmond, Indiana, the greatest diameter of the entire shell is stated to be $1\frac{1}{10}$ inches, and its convexity as about $\frac{3}{10}$ inch. No description nor figure of the cross-section is given, and the character of the surface markings is unknown.

Oxydiscus subacutus Ulrich[1] from the upper Trenton at Danville, Kentucky, displays the general structure of the genus very well, and figures of this species are here introduced (Plate XXXIV, figure 7 *a*, *b*) for comparison.

Salpingostoma richmondense Ulrich
Plate XXXIV, Figure 8

Salpingostoma richmondensis Ulrich, Geol. Minnesota, 3, pt. 2, 1897, p. 903, pl. 67, figs. 39, 40.

Inner volutions depressed, transversely elliptical, width equalling slightly more than twice the height; lateral margins sharply rounded. In the latter half of the last volution the lateral diameter increases slowly, but the dorso-ventral diameter increases rapidly, so that the latter moderately exceeds former just behind the apertural expansion. The latter is abrupt, not very wide, narrower above than below. Dorsal slit about 20 mm. long, and located about the same distance back from the margin of the aperture.

[1] Geol. Minnesota, 3, pt. 2, 1897, p. 913, pl. 62, figs. 62-65; pl. 82, figs. 23-25.

On the back of the second volution, where its width is 7 mm., are about seven irregular revolving ribs on each side of a narrow elevated slit-band. At intervals of about 1·5 mm., these ribs are crossed by transverse lamellæ.

Locality and Horizon. Richmond, Indiana, in the Whitewater member of the Richmond formation.

Salpingostoma (?) *lata* sp. nov.

Plate XXXV, Figure 6 *a*, *b*, *c*

Aperture triangularly ovate, expanded most at the postero-lateral angles, sides converging anteriorly, anterior margin having a broad but very shallow emargination. Margin of aperture tends to lie within a flat plane, and does not rise strongly toward the dorsal carina along the median part of its anterior outline, as in *Bucania.*

Shell strongly thickened toward the aperture, especially toward its inner lip.

Volutions broad, moderately and evenly convex on their dorsal side, rounding rapidly laterally into the deep umbilicus, lateral sides almost subangular. In one specimen, the width of the shell, at the beginning of the body whorl, at contact with the inner lip of aperture, is 18 mm.; at the same point the height is 8 mm., width being considerably greater than height. Width of umbilicus about 8 mm., exposing the preceding volutions.

Slit-band narrow, slightly elevated above general convexity, bordered laterally by thin raised lines, between which are the lunulæ. The transverse striæ on the surface of the shell form an angle of 75 degrees with the slit-band. The diagonally arranged riblets incline at an angle of 10 degrees with this band.

Not enough material is at hand to determine definitely that all of the specimens studied belong to the same species, although this is regarded as probable, owing to their association in the same strata at the same locality. The type chosen resembles a *Salpingostoma* in the flatness of its aperture, especially in the slight emargination and small upward curvature of the median part of its anterior margin. No trace of the open dorsal slit characteristic of *Salpingostoma* has been found, but none of the specimens expose that part of the shell where this slit would be expected to occur.

Compared with *Salpingostoma richmondensis* Ulrich, from the Whitewater member of the Richmond, Richmond, Indiana, the thickness of the shell at the aperture is considerably greater, rate of enlargement of the shell greater, and the transverse striæ more numerous.

Locality and Horizon. Specimens No. 8492, from 2 miles southwest of Wekwemikong, near the top of the hill. Also at Clay cliffs, and 2 miles northwest of Gore Bay. In the Kagawong.

Bellerophon mohri Miller
Plate XXXIV, Figure 9

Bellerophon mohri Ulrich and Scofield, Geol. Minnesota, 3, pt. 2, 1897, pl. 63, figs. 44-45.

Umbilicus small but exposing all of the volutions; lateral sides of last volution descending abruptly into the umbilicus. Slope on each side of carinated dorsum more or less flattened. Aperture broadly expanding, much wider than high; anterior margin strongly emarginated along the slit-band; inner lip strongly thickened, elevated at contact with the dorsum of the preceding volution, depressed on each side of the latter. Surface with strong transverse striæ, twelve to fourteen in a length of 5 mm.

Locality and Horizon. Richmond, Indiana, in the Whitewater member of the Richmond.

Bellerophon parksi sp. nov.
Plate XXXV, Figure 4 *a, b, c, d, e, f*

Species with a closed umbilicus; body whorl expanding rapidly toward the aperture, tending to be flaring. Inner lip of the aperture strongly thickened, the callosity thickest along the more median parts. Margin curving slightly forward. General surface along the inner lip tends to be flat, the lateral parts of the aperture curving forward in such a manner as to produce a more or less rectangular outline along the posterior part of the aperture.

Slit-band elevated on a distinct but low carina, defined on each side by a thin raised line, between which are the lunulæ. In the immediate vicinity of the slit-band, the transverse striæ curve strongly backward.

This species differs from *Bellerophon mohri* Ulrich, from the Whitewater member of the Richmond, Richmond, Indiana, in its closed umbilicus.

Named in honour of Prof. W. A. Parks, for many years an eminent student of the Ordovician faunas of Canada.

Locality and Horizon. Specimens No. 8490, from Clay cliffs. Also at Kagawong falls, and 7 miles north of Meaford, west of the road to Cape Rich. In the Meaford.

Liospira micula (Hall)
Plate XXXIV, Figure 10 *a, b, c;* Plate XXXVI, Figure 2 *a, b*

Liospira micula Ulrich and Scofield, Geol. Minnesota, 3, pt. 2, 1897, p. 994, pl. 68, figs. 24-29.

Shell lenticular, with a very low depressed spire; sutures not readily recognizable; edges sharply rounded; umbilicus filled by a reflexed callosity of the inner lip. Surface of this filling concave, but generally distinctly outlined from the remainder of the lower surface of the shell. The slit-band occupies the periphery, but with at least twice as much visible when viewed from above, than when viewed from below. Transverse striæ extremely fine and low.

Locality and Horizon. Originally described from the Maquoketa member of the Richmond formation in Wisconsin, and found at the same horizon in Illinois, Minnesota, and Iowa. It occurs in the Eden formation of Ohio and Indiana, probably also in the Maysville of these states; in the Trenton of Kentucky; and is known, also, from New Jersey, Indiana, and Tennessee.

Specimens (No. 8464) 13 and 14 mm. in diameter, with closed umbilicus, similar to *Liospira micula*, occur in considerable abundance in the loose blocks cast up by the waves on the southeastern shore of Snake island; they are associated with *Ctenodonta albertina* Ulrich, and belong to the Waynesville member of the Richmond formation.

Liospira helena (Billings)
Plate XXXVI, Figure 1 *a, b, c*

Pleurotomaria helena Billings, Canadian Nat. Geol., 5, 1860, p. 165, fig. 8.

Shells attaining a maximum diameter of about 43 mm. Spire low, forming an apical angle of about 125 degrees. Upper surface of whorls moderately concave, rising along a narrow line at the peripheral border and also toward the sutures. At the suture, inner edge of the body whorl slightly below the level of the outer edge of the next inner whorl, and commonly separated from the latter by a narrowly impressed sutural groove. Toward the apical end of the spire this sutural groove usually disappears, and adjacent edges of the whorls meet at about the same level.

The peripheral band occupies the lateral raised margin of the whorls. On the vertical lateral slope is a faint limiting line, about 1·5 mm. from the top of the margin in shells 35 mm. in diameter. On the upper face of the whorl is a similar limiting line at the same distance from the top of the raised margin.

Lower side of the body whorl comparatively evenly convex, but laterally, near the peripheral border, the slope is almost vertical for a short distance. The umbilicus varies greatly in different individuals, from comparatively narrow in smaller specimens to comparatively broad in larger ones. Umbilicus closed, at various depths in all specimens.

Inner lip of the aperture strongly thickened along its entire length.

The transverse striæ curve almost vertically downward or slightly forward from the peripheral border for a distance of 4 or 5 mm., and then more or less strongly backward toward the umbilicus. On the upper side of the whorls, these striæ curve obliquely forward from the peripheral line toward the suture.

The shell varies in thickness from 0·4 mm. on the sides of the body whorl to nearly 3 mm. at the bottom of this whorl, where the shell is thickest. On the upper side of the whorl, the shell varies from 0·4 mm. along its middle, to 2 mm. at the suture, and 3 mm. along the peripheral band.

Locality and Horizon. The types, No. 2122, were described from Clay cliffs. Additional specimens, No. 8489, obtained 2 miles southwest of Wekwemikong, near the top of the hill. Also north of the lighthouse at Manitowaning. At all of these localities it is known only from strata above the *Columnaria* reef, or in the reef itself. This would place it above the Meaford member of the Richmond, among those strata which are correlated with the Whitewater member of the Richmond.

Eotomaria canalifera Ulrich
Plate XXXIV, Figure 11

Eotomaria canalifera Ulrich, Geol. Minnesota, 3, pt. 2, 1897, p. 1002, pl. 69, figs. 9-14.

Apical angle increasing from 80 or 85 degrees in more apical parts of the shell to 100 degrees in the flatter mature shells. Slit-band sharply defined, channel-like, slightly overhanging the suture. Moderately convex below. Umbilicus very small. Transverse striæ rather unequal, never strong.

Locality and Horizon. Originally described from the Murfreesboro member of the Stones River formation, Tennessee.

Two specimens from the *Proetus* zone, of the Lorraine, appear to bear some resemblance to this species, one from Chambly Canton, the other from Vars.

Eotomaria remotistriata sp. nov.
Plate XXXVI, Figure 3 *a*, *b*

Shell with a low spire, upper slopes diverging with a wide apical angle. On close examination the inner half of the upper surface of each whorl is seen to be gently convex, the lower half, as far as the peripheral band, being gently and broadly concave. The peripheral band forms the acute outer margin of the upper face of each whorl, and is in contact with the top of the next whorl. The transverse striæ rise sharply above the general surface at equal intervals, seven occupying a distance of 4 mm., measured transversely. Compared with *Eotomaria canalifera* Ulrich, they are relatively more distant.

Largest specimen found so far 10 mm. in diameter, suggesting a species of small size.

Locality and Horizon. Specimen No. 8456, from bank of Richelieu river, below the dam at Chambly Canton, in the *Proetus* zone of the Lorraine. Another specimen, No. 8457, was found 1·5 miles northwest of Vars, at a crossing of the railway track.

Clathrospira subconica (Hall)
Plate XXXIV, Figure 12; Plate XXXVI, Figure 4 *a*, *b*

Clathrospira subconica Ulrich and Scofield, Geol. Minnesota, 3, pt. 2, 1897, p. 1006, pl. 69, figs. 47-50; pl. 70, figs. 5-6.

Shell with relatively straight profiles along its upper face, from its apex to the angular peripheral outline. Slit-band vertical, occupying the outer edge of periphery. Lower margin of the slit-band in contact with top of the next following whorl. Lower surface of the body whorl evenly convex.

Locality and Horizon. Originally described from near the base of the Trenton in New York. Apparently ranging from the Black River and Trenton to the Richmond, from New York and Canada to Ohio, Tennessee, Iowa, and Minnesota.

Two specimens, No. 8458 *a* and *b*, were found in the Nicolet River section, the first in the Waynesville. It is 30 mm. in height, apical angle

75 degrees. The second specimen was found 77 feet below the horizon at which *Rhynchotrema perlamellosa* is associated with the lowest specimens of *Strophomena planumbona.*

A specimen, No. 8459, 20 mm. high, apical angle 72 degrees, was found at Clay cliffs, in the Meaford. Another specimen, No. 8486, was found at the same horizon 7 miles north of Meaford, along the hill front west of the road to Cape Rich. It is known also from the Waynesville member near Vars. At Weston, Ontario, it occurs in the *Pholadomorpha* zone.

Lophospira (?) *hyacinthensis* sp. nov.

Specimens known so far only in the form of fragments which suggest an apical angle of about 25 to 30 degrees and the presence of about eight volutions. Peripheral band tricarinate, median carina more prominent than the limiting striæ along its upper and lower border. Slope above the peripheral band concave as far as a carina located half-way between the band and the suture; a slight distance above the middle of this concave slope is a single strong, revolving striation, similar to those on the lower surface of the body whorl. A second, but more obscure, carina occurs just beneath the suture. Lower half of the body whorl, below the peripheral band, rather evenly convex, and characterized by coarse, equally distant revolving striæ. Transverse striæ, numbering about six in a length of 3 mm., nearly perpendicular to the revolving striæ on the lower half of the body whorl; until near the peripheral band where they curve strongly backward a short distance. The two groups of striæ, revolving and transverse, form squares or rhombs. Above the peripheral band, the transverse striæ curve forward a short distance and then ascend the upper slope of the whorl at a steep angle.

The relationship of this species to *Lophospira* is indicated by the strongly tricarinate slit-band on its peripheral margin; it appears to be allied to the *Lophospira robusta* Lindström group, but the spire is much more elevated.

The term *Ruedemannia* was intended to cover those species of *Lophospira* which were included by Ulrich in his *L. robusta* group, but the species *L. lirata* Ulrich was chosen as the type. This is a species having a distinctly trilineate peripheral band, as in typical *Lophospira*, but the whorls are rotund rather than angular and the lower surface of the body whorl is striated parallel to the band.

In *Seelya ventricosa* Ulrich, the genotype of *Seelya*, the slit-band is distinctly concave, not trilineate, revolving striæ coarse, and resemble narrow plications more than striations, and the vertical striæ relatively indistinct.

Lophospira hyacinthensis is differentiated from any other species of *Lophospira* known by its sharp revolving striæ.

Locality and Horizon. At the extreme southeastern end of the exposures below the dam at St. Hyacinthe, in the *Cryptolithus* zone, Lorraine (No. 8465).

Lophospira belli sp. nov.
Plate XXXVII, Figure 3 *a, b, c*

Species belonging to the *Lophospira bicincta* (Hall) group, but readily distinguished from that species by the presence of two carinæ on the upper side of the whorls. The upper and more distinct at the deeply impressed suture; the lower and far less prominent defined chiefly by the intervening depression of the surface of the shell, located between a fourth and a third of the distance from the upper carina toward the peripheral band. General slope of the upper surface of the whorl between the upper carina and the peripheral band gently concave. Peripheral band trilineate. Below the band, lower surface of the body whorl concave as far as a distinct but rather narrow carina, situated nearly as far below band as the lower one of the upper two carinæ is above the band. Umbilicus nearly closed by the reflexed inner lip of the aperture, remaining as a narrow vertical groove. Transverse striæ, when well preserved, sharply defined; appearing slightly lamellose in those specimens in which they alternate in size. Toward the peripheral band they curve backward, somewhat as in *L. obliqua* Ulrich and Scofield (Plate XXXIV, Figure 13).

Specimens attain a height of 25 mm. The apical angle varies usually between 60 and 65 degrees, but may be as much as 75 degrees.

Named in honour of Robert Bell, of the Geological Survey, Canada.

Locality and Horizon. Clay cliffs in the Meaford (No. 8504).

Lophospira laticarinata sp. nov.
Plate XXXVII, Figure 4 *a, b, c*

Compared with similar *Lophospira elevata* Ulrich and Scofield (Plate XXXIV, Figure 14), from the Trenton of Iowa, similar in apical angle, number of volutions, width of peripheral band, presence of a carina along the lower side of the body whorl, and absence of a carina along the upper margin of the whorls. Its most characteristic feature is the peripheral band, which is relatively broad and abruptly defined along its upper and lower margins by distinct angles; the surface of band either flat or gently convex, without any evidence of trilineation in any of the specimens at hand. In some specimens the suture between the larger whorls is sharply impressed, but there is no trace of a distinct carina at the top of these whorls. The lines of growth do not appear to have been prominent, since they leave no conspicuous trace on the silicified shells at hand.

Locality and Formation. Two miles southwest of Kagawong, along the road to Gore Bay, in the Kagawong (No. 8469).

Lophospira tropidophora (Meek)
Plate XXXIV, Figure 15

Lophospira tropidophora Ulrich and Scofield, Geol. Minnesota, 3, pt. 2, 1897, p. 978, pl. 72, figs. 36-39.

Apical angle 75 or 80 degrees; volutions about five; peripheral angle relatively broad, rounded, and only moderately carinate. No evidence of trilineation along the peripheral band; upper and lower margins of band outlined by fine, limiting lines. Transverse striæ somewhat lamellose where well preserved. Columellar lip thick and slightly twisted below.

Locality and Horizon. Originally described from Cincinnati, Ohio, where it ranges from the Eden and Maysville. It is distributed in Ohio, Indiana, Kentucky, and Tennessee.

Similar specimens, requiring further study, have been found at the *Modiolopsis concentrica borealis* horizon, about a mile south of Clay cliffs (No. 8503).

Others occur above the *Columnaria* horizon, in the Kagawong, 2 miles southwest of Wekwemikongsing and also 4 miles southwest of Little Current. In the Meaford member, 7 miles north of Meaford. In the Lorraine-like strata, east of Streetsville. In the Waynesville member, in the Nicolet River section, and below the Coral zone on Snake island.

Lophospira manitoulinensis sp. nov.

Plate XXXVI, Figure 5 *a, b, c, d*

In its general form resembling *Lophospira sumnerensis* Safford (Plate XXXIV, figure 17), from the Trenton of Tennessee. Peripheral carina prominent along the earlier whorls, but some are so much less prominent near the aperture as to produce a sub-rectangular profile there. Upper surface of the whorls, from the peripheral band to the suture, strongly and evenly concave. Distance between successive peripheral carinæ sufficient to permit the upper parts of the lower whorls to approach the sutures above at a steep angle and still leave a considerable part of the lower surface of the next upper whorl exposed. The spire of *L. manitoulinensis* tends to be taller than that of *L. sumnerensis*, more of the lower part of the whorls is exposed, and there is a distinct tendency toward a low angulation along the lower part of the body whorl.

Compared with *L. tropidophora* Meek, from Cincinnatian formations at Cincinnati, Ohio, the peripheral carina is more prominent and more angular. The spire tends to be higher, and the suture at the top of the body whorl leaves a larger part of the lower side of the next upper whorl exposed. Umbilicus closed, but there still remains a narrow vertical groove between the reflexed edge of the inner lip and the neighbouring part of the shell.

Considerable variation is noted in the apical angle which varies from 55 to 70 degrees, the more acute being more common.

Shells attain a height of 45 mm.

In the taller-spired forms, more of the lower side of the whorls remains visible; in lower-spired forms, the apical part of the shell resembles *L. sumnerensis*, but the peripheral band is more acute, projects farther laterally, and there is a distinct tendency toward angulation along the lower side of the body whorl.

Locality and Horizon. Clay cliffs (No. 8501); 2 miles northwest of Gore Bay at the top of the hill along an east and west road (No. 8502) and 2 miles southwest of Kagawong. In the Richmond formation.

Lophospira bowdeni (Safford)
Plate XXXIV, Figure 16

Lophospira bowdeni Ulrich and Scofield, Geol. Minnesota, 3, pt. 2, 1897, p. 986, pl. 72, figs. 40-43.

Apical angle averaging about 27 degrees; volutions eight to ten; peripheral angle only moderately prominent. Upper slope of whorls obscurely carinated near the suture, but more or less concave between this carination and the peripheral band. Along the lower side of the body whorl is another carination, usually obscure and never sharp. Umbilicus minute, usually more or less covered by the reflexed inner lip of the aperture. Surface striæ curving backward into a strong V-shaped notch at the peripheral band.

Locality and Horizon. From the Catheys member of the Trenton in Tennessee. Usually assumed to range from the Trenton to the Richmond formation. Distributed from Tennessee to Kentucky, Ohio, and Indiana.

Specimens of the *L. bowdeni* group, but not carefully compared with *L. beatrice*, occur in the Lorraine *Pholadomorpha* zone in the Nicolet River section, and also at Streetsville.

In the Waynesville they occur at Streetsville, 7 miles north of Meaford, and at Clay cliffs.

Lophospira beatrice Foerste
Plate XXX, Figure 8 *a, b*

Lophospira beatrice Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 310, pl. 2, figs. 8 *a, b*.

The species from Huron river listed by Billings[1] under the name *Murchisonia beatrice* is a species of *Lophospira* undoubtedly closely related to *L. bowdeni* (Safford). The specimens figured by Safford represent one extreme of development, with apical angles of 27 to 30 degrees, and with eight to ten volutions, of which six or seven usually are preserved, the tip being broken off. The characteristic feature of this group of shells is the rather broad and convex peripheral band, situated slightly below the centre of the whorl, varying considerably in prominence but usually far less angular than in most other species of this genus. Upper slope flattened or moderately concave toward the peripheral band, angulated or obscurely carinated where it curves into the rather deep sutural area. Lines of growth strongly recurved toward the peripheral band, which they cross as rather broadly concave lines, indicating a rather broad notch in the outer lip. There are no raised lines or striæ bordering the upper and lower parts of the peripheral band, as in so many species of this genus. On some specimens a carination along the lower surface of the body whorl is seen; usually obscure but in some fairly distinct. Aperture not well preserved in any specimens at hand, but enough to indicate that it had essentially the same form as that of *L. bowdeni*.

The chief difference between *L. beatrice* and typical *L. bowdeni* consists in its larger apical angle, apparently averaging about 35 degrees, but varying from 30 to 38 degrees. This produces a shorter shell, so that the

[1] "Geology of Canada, 1863."

greater number of specimens, in their present state of preservation, present only four or five volutions although the complete shells possessed seven or eight.

The specimens here used as types of *L. beatrice* formed part of a small group of shells in a small tray in the collections of the Geological Survey, Canada, at the Victoria Memorial Museum, Ottawa, Canada. They were accompanied by the original printed label used for the Billings types, bearing the following information: "*Murchisonia beatrice* Billings. Rivière des Hurons. Hudson River group. Collected by James Richardson." The specimen used for figure 8 *a* is numbered 8417; 8 *b* is 8417 *a*. This species was named, but not described nor figured by Billings.

Locality and Horizon. Its horizon is regarded as corresponding to the Waynesville. Similar forms occur at the same horizon in the Nicolet River section and three-fourths of a mile west of Vars. They were not detected in the Lorraine section exposed along Nicolet river.

Lophospira kindlei sp. nov.

Plate XXXVII, Figure 1 *a*, *b*, *c*, *d*

Species resembling *Lophospira notabilis* Ulrich (Plate XXXIV, figure 18), from the Black River limestone of central Tennessee, although with notable differences. As in that species, the peripheral band is on a broad and prominent carina. Band itself comparatively flat, and either slightly concave or gently convex, crossed by lunulæ, but there is no indication of the trilineate structure characteristic of typical *Lophospira*. Upper side of the whorls distinctly carinated at about the same elevation as the suture, but quite 2 mm. from the latter toward the aperture of the shell. Between carina and the peripheral band, upper surface gently concave, except in the immediate vicinity of the peripheral band where the curvature increases. There is a carina also along the lower side of the body whorl, closer to the peripheral band than the upper carina. Between lower carina and peripheral band, shell distinctly concave, the curvature being greatest at the band. The transverse striæ curve distinctly backward toward the peripheral band, distinctly above the band, more moderately below it. Umbilicus almost closed by the reflexed inner lip of the aperture, remaining as a narrow, vertical groove. The shell attains a vertical height of 30 mm. Apical angle varies between 65 and 70 degrees.

This species differs from *L. belli* in its broad, flat, peripheral band, not trilineate, and in the absence of a second carina along the upper side of the whorls.

Locality and Horizon. Clay cliffs, in the Meaford (No. 8505).

Hormotoma gracilis angustata (Hall)

Plate XXXIV, Figure 20

Hormotoma gracilis angustata Ulrich and Scofield, Geol. Minnesota, 3, pt. 2, 1897, p. 1015, pl. 70, figs. 30-36.

Shell elongate, with apical angle of about 17 degrees. Volutions numerous, eight to ten or more, with rounded profiles. Peripheral band flat or slightly concave, margined on each side by a delicate, raised line.

Transverse striæ fine, curving backward at the peripheral band. Compared with other varieties of the species, this form is more uniformly rounded, and the band slightly wider.

Locality and Horizon. Described originally from the Black River at Watertown, New York. Widely distributed at this horizon from Canada to Virginia, Tennessee, Wisconsin, and Minnesota.

Specimens, up to 35 mm. in length, occur at Tamarack point, in the Sheguiandah. Usually they are covered by a thin, encrusting bryozoan.

Hormotoma gracilis sublaxa Ulrich

Plate XXXIV, Figure 19

Hormotoma gracilis sublaxa Ulrich and Scofield, Geol. Minnesota, 3, pt. 2, p. 1015, pl. 70, figs. 23-25.

This variety may be recognized by the greater obliquity of its whorls and sutures and its relatively wide peripheral band. In typical specimens, the obliquity of the whorls equals an angle of 65 degrees with the vertical axis.

Locality and Horizon. Originally described from the Auburn member of the Black River, Missouri.

Specimens with very oblique sutures occur in the Lorraine, *Cryptolithus* and *Leptæna* zones in the Nicolet River section; in the *Proetus* zone at Chambly Canton; in the Meaford at Kagawong falls.

Helicotoma brocki Foerste

Plate XXXIV, Figure 23 *a*, *b*

Helicotoma brocki Foerste, Bull. Denison Univ., 17, 1912, p. 137, pl. 10, fig. 11; pl. 11, fig. 3.

Helicotoma brocki is similar to *Helicotoma planulata* Salter (Plate XXXIV, figure 21), from the Black River formation of Ontario, New York, Wisconsin, and Missouri, in having distinct revolving striæ along the lower half of the body whorl. The striæ in *H. brocki*, however, are much stronger, and, therefore, the lower part of the body whorl appears more protuberant. There are five revolving striæ; of these, two occupy the most prominent part of the lower half of the whorl, and each of the striations immediately above and below these two is equally distant and equally prominent. The fifth striation, at the outer edge of the flattened base of the body whorl, is less prominent than the other four, and is a relatively shorter distance from the striation next above. Under side of the whorls strongly flattened or faintly concave, with a rise of the surface at the margin of the umbilicus. Transverse striæ very fine, but distinctly visible under a lens. On the lower surface of the whorls they form an angle of 50 degrees with the outer margin; on the outer sides they form an angle of 30 degrees with the perpendicular; and on the upper side they turn strongly from the marginal notch ridge toward the apertural end for a short distance and then approach the inner edge of the whorls, at the sutures, at an angle of 55 degrees. Umbilical slopes steep, departing from the vertical at an angle of only 10 degrees. In *H. planulatoides* Ulrich (Plate XXXIV, figure 22) there are no revolving lines.

Locality and Horizon. Kagawong falls in the Meaford (No. 8128).

Cyclonema bilix conicum Miller

Plate XXXIV, Figure 24; Plate XXXVII, Figure 2 *a*, *b*

Cyclonema bilix conica Miller, Cincinnati Quart. Jour. Sci., 1, 1874, p. 320.
Cyclonema bilix Meek, Geol. Surv., Ohio, Pal. 1, 1873, pl. 13, fig. 5 *g*.

Shell conical, relatively tall, with an apical angle of 55 to 60 degrees, tending toward angulation along the lower part of the body whorl. Umbilicus absent, inner lip thickened, reflected, and more or less excavated. Revolving striæ prominent, crossed by fine, transverse lines.

Cyclonema bilix was described by Conrad from Richmond, Indiana, and was stated to occur in limestones the age of the rocks of the Salmon River series, in New York. The Salmon River series of Conrad included about the same strata as the Lorraine in its broadest sense, but the most conspicuous element of the Salmon River was the practically unfossiliferous sandstone at the falls. Evidently Conrad obtained his specimens of *C. bilix* from some locality near Richmond, Indiana, but it is an anomalous fact that the figure accompanying his original description does not represent the conical form typical of the Whitewater at Richmond, Indiana, but the Brassfield form at Elkhorn Falls, 3 miles southeast of Richmond. It is strongly suspected, therefore, that the type of *C. bilix*, now lost, was the Brassfield and not the Richmond form found in the Richmond, Indiana, area.

Locality and Horizon. This variety is based upon figure 5 *g*, Plate 13 of the Geological Survey of Ohio, Palæontology, vol. 1, 1873; it probably represents a Richmond form, from some part of Ohio or the adjacent part of Indiana. At any rate, specimens having this form are common in the Richmond, especially in the Whitewater member of this formation.

The typical conical form of the Richmond formation occurs at numerous localities in the Waynesville in Ontario and Quebec, including McLean hill, Clay cliffs, 6 and 7 miles north of Meaford, Workman brook 3 miles southeast of Meaford, Oakville, Streetsville, in erratic blocks on Yamaska river, and in the Nicolet River section.

Holopea nicolettensis sp. nov.

Plate XXXVI, Figure 6 *a*, *b*, *c*

Shell with at least five volutions; width about 24 mm.; height estimated at about 30 mm.; the spire rising 14 or 15 mm. above the body whorl at the aperture. The spire appears to have been crushed downward, so as partly to telescope the volution next to the body whorl. Body whorl of moderate height but strongly ventricose, rather evenly rounded. Exterior margin of aperture also evenly rounded; inner lip folded back but leaving a narrow vertical slit at the umbilicus. Owing to distortion by pressure, the outer lip is pushed toward the inner lip, resulting in a relatively narrow aperture, but this originally probably had about the same outline as in other forms referred to *Holopea*.

The spire has a greater height than that of *H. insignis* Ulrich and Scofield (Plate XXXIV, figure 25).

Locality and Horizon. Nicolet River section, in the Waynesville (No. 8454).

Pterotheca clochensis sp. nov.
Plate XXX, Figure 3

Pterotheca cf. *attenuata* Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 312, pl. 2, fig. 3.

Shell small, 20 mm. wide and 17 mm. long. Convexity of 3 mm., but anterior part of sharp median carina rises nearly 4 mm. above adjoining part of body. Postero-lateral angles rounded. Sutures locating the lines of attachment of the lateral sides of septum to the under side of shell 10 or 11 mm. in length and diverging at an angle of 78 degrees. Along the sides of the median carina the concentric striæ curve upward and backward.

Locality and Horizon. From the basal red clay shale of the Lowville, along the western shore of La Cloche peninsula, Manitoulin islands.

P. saffordi (Hall), from the Lebanon member of the Stones River formation, at Lebanon, Tennessee, is known only from a specimen whose posterior margins appear to diverge at an angle of 114 degrees, viewed directly from above, judging from the attenuation of the margin of the shell along its supposed posterior margin. *P. attenuata* (Hall), from the Platteville member of the Black River at Beloit, Wisconsin, is figured as having a posterior angle of about 80 degrees. *P. canaliculata* (Hall), from the Trenton at Middleville, New York, apparently had a more quadrate outline, judging by one of the type series, although none preserves the posterior margin.

P. expansa (Emmons), from the Black River of Watertown, New York, and *P. anatiformis* (Hall), from the Trenton of Watertown, New York, are much broader shells of the quadrate type.

P. undulata (Hall), from the Trenton of Watertown, New York, is a quadrate shell in which the width is only moderately greater than the length, thus contrasting with the two species mentioned last. Its surface is wrinkled conspicuously in a concentric manner. Since the type of *P. undulata* has been lost, and several forms of *Pterotheca* from the Trenton and Black River of New York are concentrically wrinkled, it is uncertain which form Hall used as the type of his species.

In outline *P. clochensis* resembles *P. undulata,* but it is a much smaller shell without any trace of conspicuous concentric wrinkling.

P. angusta Raymond, from the highest layers of the Cobourg or upper Trenton, at Collingwood, Ontario, has a sharply angular, median ridge. The platform on its lower face has sides diverging at an angle of 60 degrees.

The species of *Pterotheca* listed by Prof. Twenhofel from the English Head and Vaurial formations of Anticosti island is one of the broad, more quadratic forms of the genus, and not a triangular form. By Billings it was listed as *P. transversa* Salter.

British Species of Pterotheca. The genus *Pterotheca* is founded on *Atrypa transversa* (Portlock); this species was described originally from the Upper Ordovician of Desertcreat, in Tyrone, Ireland.[1] It was figured in Murchison's Siluria, first edition, 1854, page 196, and the same figure was repeated in subsequent editions. The original specimen, No. 23110, is preserved in the Museum of Practical Geology in London, and an excel-

[1] Rept. Geol. Londonderry, 1843, p. 455.

lent cast was presented to the writer by Dr. F. A. Bather. Ashgillian (Upper Bala) strata are exposed in the northwestern part of Ireland in county Tyrone.

P. transversa (Portlock). Type specimen 43 mm. wide and 28 mm. long, measured to the edge of anterior border on each side of median carina; measured along this carina, the length is 30 mm. Posterior sides of shell diverge at an angle of 135 degrees, lateral sides broadly rounded, but not as broadly as the anterior margin, which, except at the carina, is only gently convex. The carina may have been 3 mm. in height anteriorly, but only its basal portion is preserved. Septum on the lower side of the shell fully exposed; extending about 19 mm. anterior to beak, its lateral margins, at their attachment to the lower surface of the shell, diverge at an angle of 55 degrees near the beak, increasing to 85 degrees at their anterior extremities. Septum flat, its anterior margin very moderately convex, even less so than that of the anterior margin of the shell. Concentric wrinkles much less conspicuous than in *P. undulata* (Hall), though about as strong as those of *P. mullochensis* Reed. There are traces of very fine radiating striæ.

P. corrugata Salter (MSS.) is a British species from the "Caradoc." *P. undulata* Salter (MSS.) is listed from the Ordovician of North Wales and Shropshire. *P. avirostris* Salter (MSS.) is from the Woolhope and Upper Llandovery beds of western England. Prof. F. R. Cowper Reed has described five species of *Pterotheca* from the Girvan district of Scotland, ranging in age from the Caradocian to the Upper Valentian, of the Silurian.

Bohemian Species of Pterotheca. Barrande described one Bohemian species *P. bohemica.*

Pterotheca belongs to that group of species, occurring in the Ashgillian of northwestern Ireland, which have a strong American facies. Grenville A. J. Cole states[1]: "The Irish area in Ordovician times was practically marine. * * Continental land must have long remained where the North Atlantic now spreads its waters." The Ashgillian fauna in question must have migrated in Ordovician time along the southern border of this hypothetical continental land.

Pterotheca harviei sp. nov.
Plate XXVI, Figure 6

General outline of shell appears to have been broadly ovate. Surface apparently of moderate convexity in a lateral direction. The median part of the shell rises into an acute ridge or carina, which, at a distance of 40 mm. from the apex, rises with a base of 7 mm. to a height of 4 or 4·5 mm. above the general convexity of the shell. Height of the carina small, contrasted with the width of the shell, which is 75 mm. Original length of the shell probably 60 mm., judging from the outline as far as preserved. The lines of junction between the lateral margins of the septum and the lower surface of the shell extend from the apex diagonally forward for a distance of 40 mm., diverging at an angle of 98 degrees. Convexity of the septum less than that of the shell, but is in an upward direction, the same as in the latter. Near the apex, the median part of the septum is elevated

[1]Geology of the British Isles, 1918, pp. 80, 81.

slightly for a width of 5 mm. at a distance of 2 mm. from the apex; how much farther forward this elevation extended is unknown. The posterior part of the shell, on both sides of the carina, is wrinkled in a direction parallel to this carina.

Locality and Horizon. Two miles northwest of St. Hugues, on Yamaska river, in the *Cryptolithus* zone of the Lorraine formation (No. 8584), collected by Robert Harvie.

P. harviei belongs to the group of species, ovate in outline, which includes *P. attenuata* and *P. saffordi*. *P. harviei* resembles *P. saffordi* most nearly in outline, but it is a much larger species, of less convexity, and the median carina relatively narrower and less strongly elevated.

Pterotheca pentagona Foerste

Plate XXX, Figures 1, 2

Pterotheca pentagona Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 313, pl. 2, figs, 1, 2.

Shell with distinct but rounded angles at the two postero-lateral, the two antero-lateral, and the antero-median parts of its outline. Lateral sides subparallel. Antero-lateral sides moderately concave. Postero-lateral sides apparently nearly straight. Length of the shell estimated at 35 to 37 mm. Its present convexity, not including the carina or keel, estimated at 5 to 7 mm., but its original convexity may have been considerably greater.

Only the basal part of the carina along the anterior half of the shell is preserved. Carina at least 10 mm. in height, possibly higher. Shell finely striated concentrically, striæ following lateral and anterior outlines of the shell. At the base of the carina striæ curve backward and upward suggesting a vertical slit anteriorly. Shell wrinkled concentrically, wrinkles being developed best between the apex and the postero-lateral margins.

Lower side or aperture traversed posteriorly by a broad, triangular septum reaching the apex of the shell and joining the lateral sides of the shell along nearly straight, divergent lines which subtend an angle of 75 degrees with each other. These lines of attachment are about 20 mm. long. Striæ on this septum indicate that its anterior outline was moderately convex. The septum curves in the same direction as the shell, but to a much smaller degree.

Locality and Horizon. Richelieu river, near Chambly, collected in 1881 by A. H. Foord. In the *Proetus* zone of the Lorraine (No. 2155).

A second specimen, in the *Proetus* zone, was found in the Nicolet River section (No. 8409).

Endoceras sp.

Fragment of a siphuncle, 130 mm. long, 32 mm. in diameter at the smaller end, and approximately 40 mm. at the larger extremity. In that part of the conch which surrounded this fragment, 11 cameræ occupied a length of 120 mm. Siphuncle evidently distinctly excentric in location, since the annular markings locating the top of the septal necks slope strongly downward from one side to the opposite one. Septal necks not preserved sufficiently well to determine whether they extend downward only the length of one chamber or of two. A part of the conch is preserved and this suggests a diameter equal to about twice that of the siphuncle.

The genus *Endoceras* is characterized by the presence of long, conical endocones. Usually the number of endocones in the same specimen is small, usually only one or two being found. In *Vaginoceras* the number of such endocones is supposed to be considerable. In *Cameroceras*, on the other hand, endocone cylindrical along the greater part of its length, but narrows abruptly at its lower end to a conical tip whose upper part not infrequently is more or less bulbously inflated. The bulbous portion faces the interior of the conch. One side of the conical tip is in contact with the ventral side of the siphuncle, along its entire length, and, therefore, is in line with the upper part of the endocone. Opposite side more or less strongly oblique to the axis of the siphuncle, sloping from its dorsal toward its ventral side. Both cylindrical part of the endocone and that part of the conical tip facing the ventral side of the conch more or less obliquely annulated, annulations corresponding to those of the enclosing siphuncle. Inner walls of conical tip lined with a calcareous deposit, increasing in thickness towards its lower end. The lower end is entirely filled, but farther up it is sufficiently thick to reach only the centre of the endocone except at its top where a funnel-shaped vacant space remains. This calcareous deposit, with greatly reduced thickness, continues upward so as to include the lower part of the cylindrical portion of the endocone.

Location and Horizon. Clay cliffs, in the Meaford.

Billingsites manitoulinense sp. nov.

Plate XLII, Figure 1 *a*, *b*, *c*, *d*

The fragment consists of the gerontic top of a cyrtoceraconic shell. Ovoid in form, dorsal outline concave lengthwise, extending from the straight sutures crossing the fragment obliquely at its base and continuing to the top of the specimen. The fact that even the lower part of the dorsal outline of the ovoid gerontic enlargement of the conch is concave will distinguish this species from any other with which it is likely to be compared. Specimen compressed laterally, ratio of the lateral to the dorso-ventral diameter being 20 to 23. Toward its top, it contracts, especially dorso-ventrally, diameter in this direction from 23 mm. near the base to slightly over 15 mm. at the top. If the top of this gerontic part of the conch terminates in a cylindrical neck, as in *Ascoceras bohemicum* Barrande, this neck is broken off.

Judging from the size of the septum forming the base of the gerontic enlargement the lower part of the conch to which it was attached apparently was of large size. The suture of the septum forms an angle of 50 degrees with the vertical axis, rising strongly dorsally. A second septum, 2 mm. farther up, is strictly parallel to the first. The suture of the third septum is about three-fourths of a millimetre distant from the suture of the second along its ventro-lateral course, but rises from the latter with a sigmoidal curvature until it reaches a point 5·5 mm. above the latter along the median part of the dorsal side of the conch. The suture of the fourth septum appears in actual contact with the preceding one along the ventro-lateral part of the specimen, but rises 4 mm. above the latter along the median part of the ventral side of the conch. The former presence of a fifth septum is suggested by a curved break of the shell on the right side of the specimen, but no part of this septum can be detected, the matrix which fills the upper part of the living chamber being continuous as far down as the fourth septum.

Those forms of *Billingsites* which occur in the Ordovician usually have very obese living chambers at maturity. All of these, as far as known, are confined to the Richmond. *Billingsites canadensis* has been made the type of the genus. It occurs in the English Head and Vaurial members of the Richmond on Anticosti island. *Billingsites newberryi* (Plate XXXVIII, figures 6 *a*, *b*, 7 *a*, *b*) occurs in the English Head, Vaurial, and Gamachian, and *B. anticostiense* occurs in the Gamachian of Anticosti. In his original description of *B. newberryi* Billings cites this species also from the Richmond at Cape Rich, 9 miles west of north from Meaford, on Georgian bay, but this specimen has been lost, and its relationship to *B. newberryi* cannot be determined definitely. *B. costulatum* was described from the Richmond of the Lake Winnipeg region, and *B. boreale* from the Richmond of Shamattawa river west of Hudson bay. An undescribed species occurs in the Whitewater at Richmond, Indiana. Specimens occur also in the Richmond of Bay de Noc peninsula, east of Escanaba, Michigan. Possibly the cephalopod layer at the base of the Whitewater represents a northern invasion.

Locality and Horizon. Clay cliffs, in the Meaford (No. 8452).

Spyroceras chambliense sp. nov.

Plate XXXIX, Figure 3; Plate XL, Figure 1

A single specimen, in shale, flattened by pressure, 40 mm. in width; approximate former width 30 mm., or a little more. About seven annulations in a length of 65 mm.; annulations gently convex, separated by shallow grooves, neither one distinctly defined. Surface marked by vertical striæ differing in prominence. Primary striæ occur approximately 4 mm. apart. Half-way between them are secondary ones barely one-sixth of a millimetre in width almost as wide as the primary ones. Alternating with the primary and secondary striæ is a Tertiary series. Between the primary, secondary, and Tertiary vertical striæ are relatively broad and flat intervals. There is also a series of transverse striæ, fifteen to eighteen in a length of 1 mm., visible only under a lens.

Locality and Horizon. In the shales along the southern bank of Richelieu river, several hundred yards below the dam at Chambly Canton (No. 8568).

Spyroceras hammelli Foerste

Plate XXXIX, Figure 1 *a, b;* Plate XL, Figure 3

Dawsonoceras hammelli Foerste, Bull. Denison Univ., 16, 1910, p. 74, pl. 1, fig. 4.

Orthoceracone annulated, with longitudinal striations which show no tendency toward disappearance in adolescent or adult stages.

In a specimen 85 mm. long, diameter at the smaller end 12 mm., and at the larger 19 mm., indicating an apical angle of nearly 5 degrees.

In this length there are nineteen annulations, or five annulations in a length equal to the diameter of the conch. Where the diameter is 15 mm., the more prominent, or primary, vertical striæ usually are between 1·8 and 2 mm. apart. Midway between the primary striæ are secondary ones, usually narrower and less conspicuous. Still finer, Tertiary, striæ may be detected on well-preserved surfaces. On such surfaces the stronger striæ may be elevated fully 0·2 mm. above the general surface of the shell. The intervals between the more prominent striæ tend to be slightly concave. Transverse striæ, when present, are minute.

Conchs 22 mm. in diameter are at hand, and fragments indicate that they attain larger sizes.

Septa only moderately concave. Siphuncle nearly central in location. Segments of the siphuncle nearly globular in form. In a specimen 13 mm. in diameter, where the septa are 3 mm. distant from each other, the maximum diameter of these segments is 3·7 mm., contracting to 1·75 mm. at the septal necks.

Locality and Horizon. Clay cliffs, in the Meaford (No. 8537).

Spyroceras parksi sp. nov.

Plate XXXIX, Figure 2; Plate XL, Figure 4

Closely related to *Spyroceras hammelli*, but with annulations less distinct and vertical striæ finer, and more nearly subequal in size.

In some specimens the annulations can be seen only when illuminated transversely. The direction of the annulations does not always coincide with that of the sutures, some inclining opposite to the latter.

In one specimen 110 mm. long, 17 mm. wide at the smaller end, and 26 mm. wide at the top, there are twenty-three cameræ. Septa of medium convexity. Siphuncle nearly central in position, and where the diameter of the conch is 26 mm., that of the septal necks is 3·5 mm.

Filiform vertical striæ number twelve to sixteen in a width of 2 mm., and approximately of the same size. At intervals of 1·7 to 2 mm., some of these striæ tend to be more prominent, but none are as conspicuous as those of *S. hammelli*.

Locality and Horizon. Clay cliffs (No. 8538). Named in honour of Prof. W. A. Parks.

Sactoceras piso Billings

Orthoceras piso Billings, Pal. Foss., 1, Geol. Surv., Can., 1865, p. 168 (adv. sheets, 1862).

Original Description. "Section circular, tapering eight lines in a length of 5 inches; septa moderately concave, about twelve to the inch; siphuncle moniliform, dilated, between the septa, to a diameter of about 1·5 lines, its centre distant about three lines from the margin, where the diameter of the fossil is ten lines. The shell is preserved on the specimen, and appears to be quite smooth, but this may have been caused by cleaning it from the adhesive shale in which it was found embedded. It is most probably marked with fine engirdling striæ.

"The specimen is 5 inches in length; width at the larger extremity fourteen lines, and at the smaller six lines.

"*Locality and Formation.* Cape Smyth, lake Huron. In the Hudson River group.

"Collector. R. Bell."

The type of this species has been lost and no other specimens have been found which can be referred without question to the same species.

In order to secure some idea of the general appearance of the type of *O. piso* a drawing was prepared, based on the original description. In this drawing it is assumed that the number of septa, "about twelve to the inch," was determined "where the diameter of the fossil is 10 lines." Apical angle about 7 degrees.

Sactoceras manitoulinense sp. nov.
Plate XXXIX, Figure 4 *a, b, c*

Type. Specimen (No. 8539 *a*) is 40 mm. long, 10·2 mm. in diameter at smaller end, and 15 mm. at larger extremity, indicating an apical angle of 7 degrees. In this length there are twenty cameræ. Where diameter of specimen is 11 mm., and where septa are 2·5 mm. apart, one of the segments of siphuncle has a maximum diameter of 2·8 mm. at mid-height, constricting to 1·5 mm. at its passage through the septum. The resultant form of segments of siphuncle almost globular. Along centre of siphuncle there is a cylindrical or tubular space, about 0·75 mm. in diameter, filled with material slightly different from surrounding part, and probably corresponding to the endosiphuncle. Surface of this specimen smooth; on one side are several vertical colour bands, about 1 mm. in width, separated by intervals of 0·5, 1, and 2 mm. These bands suggest colouring in original shell, but do not occur in all specimens found at the same locality and referred to the same species.

Second Specimen. Specimen (No. 8539 *b*) originally 110 mm. long, 20 mm. in diameter at the base, and 30 mm. at the top, indicating an apical angle of 5 or 6 degrees. Within this length of 110 mm. were twenty-six cameræ; however, a piece about 20 mm. long was broken off at the smaller end for the purpose of grinding down, to get at the siphuncle. This smaller piece has a diameter of about 20 mm. Centre of siphuncle about 6·5 mm. from the nearest wall of the conch. Septa 4 mm. apart. Maximum diameter of the segments of the siphuncle nearly 3 mm. at mid-height within the cameræ, contracting to 1·5 mm. where passing through the septa. General form of these segments oblong rather than globular. Interior of the cameræ lined with calcareous material about three-quarters of a millimetre thick, consisting of calcite arranged perpendicular to the septa and other walls of the cameræ. Location of the siphuncle strongly excentric along the greater part of its length, but much less so along the small fragment broken off.

Both the main body of the specimen and the small fragment show colour banding, 0·5 mm. in width and separated by intervals of 0·75 mm. to 1 mm. Shell material along the vertical bands slightly raised. A thin black film covers both the vertical colour bands and the intermediate parts of the shell, but tends to show up better on the colour bands. Evidently this vertical colour banding is due to structure belonging to the nner surface of the conch, or to one of its inner coats. The black film probably lines the entire inner surface of the shell, but shows up best on exterior view where the shell is thinnest. If this supposition be correct, then the inner surface of the shell should be marked by vertical bands of depression where the dark colour bands show up on the exterior.

Third Specimen. The shell of this specimen (No. 8539 *c*) has weathered in such a manner as to suggest that the dark vertical bands are more resistant to weathering. This specimen is 40 mm. long, 13 mm. wide at its smalller end, and 17 mm. wide at the top.

Fourth Specimen. This specimen is 70 mm. long, 13 mm. in diameter at the smaller end, 20 mm. wide at the top, and consists of twenty-one cameræ. At its base the septa are 2·75 mm. apart, and the segments of the siphuncle widen to about 2·5 mm.

Locality and Horizon. Clay cliffs, in the Meaford (No. 8539).

In *S. manitoulinense,* six or seven cameræ occur in a length equal to the diameter of the conch. In *S. piso* this number is nine, if Billing's counting of twelve septa to the inch was made where the diameter of the fossil was ten lines. If this counting was done farther up, then the number of cameræ in a length equal to the diameter of the conch would be still greater in *S. piso.*

In the size of the apical angle, and in the size and form of the segments of the siphuncle the two species probably were alike.

Ruedemann[1] found in several specimens of *Geisonoceras tenuitextum* (Hall) that the colour bands are confined to the convexly curved side of the conch, the latter being slightly curved lengthwise, as indeed are most of the so-called *Orthoceracones.* The dorso-ventral depression of the conch, which he notes, is also quite general among the *Orthoceracones.* Although both *S. manitoulinense* and *S. westonense* show an uneven distribution of the colour banding on different sides of the conch, the writer failed to connect the latter with either the dorsal or ventral side of the conch. In the case of *Geisonoceras tenuitextum,* Dr. Ruedemann regards the vertically banded side as the upper side of the conch, while the animal is at rest on the sea bottom, or crawls along slowly. He deems it as probable that "the conchs, buoyed up by gas in the air chambers, were lightly dragged over the soft mud of the bottom, by the probably sluggish animals."

Earlier, in the same paragraph, he states that "It seems improbable that the long, straight cones could have been carried horizontally in swimming, especially as these cephalopods must be assumed to have, like all their recent descendants, swum backward by the expulsion of water from the forwardly directed funnel. The often delicate shells could not have stood the shock of frequent impacts incidental to such mode of propulsion, and the prevailing preservation of the acute apex of the conchs militates against the view that such impacts could actually have occurred at frequent intervals."

In connecting the distribution of colour banding with the position of the conch during life of the animal, Dr. Ruedemann has given rise to most interesting speculations as to the life habits of the palæozoic *Orthoceracones.*

[1] "On Colour Bands in Orthoceras," New York State Mus. Bull. Nos. 227, 228, 1921, pp. 79-88.

Sactoceras westonense sp. nov.

Plate XXXIX, Figure 5; Plate XL, Figure 2

Apical angle about 8 degrees. About seven cameræ in a length equal to the diameter of the conch. Shell marked by numerous vertical bands of approximately the same width, alternately dark and light. Where the diameter of the conch is 20 mm., the number of dark bands on one side equals 6·5 in a width of 5 mm., at a distance of one-sixth of the circumference of the conch their number is nine in the same width. The colouring appears to be connected with the inner layers of the shell, so as to become visible on weathering. On the side opposite to that exposing the vertical colour bands, there is no banding, but the surface of the shell is very well preserved, exposing very fine vertical striæ, visible only under a lens, of which about fifty occur in a width of 5 mm.

It seems unlikely that this species, with its numerous narrow, subequal, vertical colour bands should be identical with *S. manitoulinense,* in which the colour bands are much broader and more irregular in size. Moreover, the very fine surface striation of *S. westonense* is regarded as characteristic.

Locality and Horizon. Weston, Ontario, in the Lorraine formation. Collected by J. B. Tyrrell (No. 2174).

Sactoceras (?) sp.

Plate XLI, Figure 6

Fragment 55 mm. long, 13 mm. in diameter at the base, and estimated to have been 25 mm. in diameter at the top, thus indicating an apical angle of 15 degrees. In this length are twenty-three cameræ. Septa moderately concave. A vertical section at the smaller end of the specimen shows only the filling of the central, more tubular part of the siphuncle, varying from 0·75 mm. to 1 mm. in diameter probably corresponding to the endosiphuncle. The siphuncle probably consisted of more or less globular segments.

This species differs from *S. piso* Billings, described from the same locality, chiefly in its much larger apical angle, the apical angle of the latter species being only 7 degrees.

Locality and Horizon. Clay cliffs, in the Meaford (No. 8541).

Kindleoceras gen. nov.

Kindleoceras is characterized by strong dorso-ventral depression of the conch, the siphonal side being much more convex, and the anti-siphonal side being strongly flattened. The sutures form low saddles on the siphonal side and shallow lobes on the antisiphonal side. Siphuncle strongly nummulitic.

In *Mixosiphonoceras* Hyatt, with *Mixosiphonoceras desolatum* (Barrande), from the Silurian of Bohemia as the genotype, the siphuncle is located on the angulate side of the conch. This genus differs from *Kindleoceras* in having the conch curved lengthwise, the siphonal side being concave. Antisiphonal side strongly and rather evenly convex, without any conspicuous flattening. Siphuncle broadly moniliform rather than nummulitic, and its interior filled with calcareous deposits in the form of vertical radiating plates.

In *Tripleuroceras* Hyatt, with *Tripleuroceras archiaci* (Barrande), from the Silurian of Bohemia as the genotype, the siphuncle is located on the flattened side of the conch, and the sutures on this side form distinct, approximately V-shaped lobes. Siphuncle strongly nummulitic.

Kindleoceras is named in honour of E. M. Kindle, palæontologist, Geological Survey, Canada.

Kindleoceras reversatum gen. et. sp. nov.
Plate XLII, Figure 2 *a*, *b*, *c*

Conch straight, slowly enlarging, apical angle in a lateral direction about 5 degrees. Conch strongly flattened on the anti-siphonal side, much more convex on the siphonal side, but even the latter is depressed convex, with a tendency toward angulation along the median area and a slight amount of flattening on each side of this area. On the lateral sides of the conch the greatest transverse convexity lies nearer the anti-siphonal or flattened side.

A length of 50 mm. of the living chamber, remains. There is no indication of the form of the aperture.

Along the middle of the anti-siphonal side nine cameræ occupy a length of 23 mm.; the sutures of the septa curve moderately downward forming broad, shallow lobes about 4 mm. in depth. Toward the base of the living chamber the median part of the sutures becomes straight or rises slightly into a faint saddle. On the lateral side of the conch the sutures rise from the antisiphonal toward the siphonal side at an angle of about 10 degrees with the horizontal. On the siphonal side of the conch the sutures continue to rise at about the same angle toward the median area of this side, crossing the latter with a convex curvature, the result being a series of low, broad saddles, increasing in altitude on approaching the base of the living chamber.

The siphuncle is located so close to the more convex side of the conch that it is exposed by a moderate amount of weathering.

Segments strongly nummuloidal.

The ventral side of any conch is that side which bears the hyponomic sinus. When the aperture is not present, the location and general form of the aperture can be determined from the transverse striæ on the surface of the conch, if the latter are retained. In the absence of any indication whatever of the location of the hyponomic sinus, it may become very difficult or even impossible to determine which side of the conch is ventral and which dorsal.

In the case of *Kindleoceras reversatum*, the sutures of the septa slope distinctly downward from the siphonal toward the antisiphonal side of the conch, and, since in a number of other straight conchs a similar downward slope is known, the flattened side of *Kindleoceras reversatum* may be regarded temporarily as the ventral side.

Locality and Horizon. Clay cliffs, in the Meaford.

Kindleoceras triangulare sp. nov.
Plate XLIII, Figures 11, 12, 13, 14

Conch distorted, ventral side pushed over toward the left viewing the specimen from the ventral side. Cross-section triangular, with the siphuncle occupying one of the angles. At present dorsal side has a convex cross-section with a radius of curvature of 14 mm.; originally it may have been a little broader and flatter. Dorso-lateral angle on the right side has a radius of curvature of slightly less than 5 mm., and that on the left of 7·5 mm. Ventro-lateral side has a radius of curvature of 10 mm., and that on the left of 20 mm. Angle along the ventral side at present has a radius of curvature of 7·5 mm. Apical angle appears to be 9 degrees, but this is uncertain in view of the short length of the fragment, and its distortion. The specimen consists of the lower part of the living chamber with five cameræ still attached. The lower three of these cameræ occupy a total length of 5·7 mm., which suggests the presence of ten cameræ in a length equal to the lateral diameter of the conch at the top of the series being counted. Since the upper two cameræ occupy a total length of 2·5 mm., the conch appears to be mature.

On the ventral side of the conch, the sutures curve strongly downward, forming relatively strong lobes; this downward curvature slightly exceeds that of one camera. The sutures rise with a gently concave curvature toward the median part of the ventral side, thus forming ventral saddles; which appears to equal nearly one camera. Siphuncle almost in contact with the ventral wall. The siphuncle consists of a series of segments intermediate between broadly moniliform and narrowly nummuloidal, but more nummuloidal than moniliform. It has a width of at least 2·5 mm. at mid-height in the cameræ, narrowing strongly in passing through the septa. The lowest segment of the siphuncle exposed appears to be filled by a calcareous deposit which is vertically grooved on its exterior, as in some *Actinoceroids*. Segments of the siphuncle strongly oblique to the vertical side of the conch, corresponding to the rise of the septa on this side of the conch.

Compared with *Kindleoceras reversatum*, from the same horizon and locality, this species is relatively much narrower, the dorso-ventral diameter being correspondingly greater.

Locality and Horizon. From the Meaford at Clay cliffs.

Actinoceras (?) *lambei* sp. nov.
Plate XLII, Figure 3 *a*, *b*

Conch apparently straight, rapidly enlarging; siphuncle strongly nummuloidal, also rapidly enlarging, and nearly in contact with one side of the conch.

Specimen with circular outline at base, having a diameter of 17·5 mm. at that point. Enlarging to a diameter of 34 mm. at a point 23 mm. above the base, suggesting an apical angle of 45 degrees; even if part of this angle were due to flattening produced by pressure previous to fossilization, the apical angle probably equalled at least 35 degrees. Sutures apparently directly transverse to the axis of the conch, only slightly concave at the base of the specimen, moderately concave farther up. Five nummuloidal segments of siphuncle are exposed, totalling 13 mm. in length; their diameters, taken in the order of their succession, are 5·2, 6·5, 9·0, 11·0, and 13·0 mm. The diameters of the constrictions at the septal necks, between nummuloidal segments, and beginning at extreme base of the specimen, are 1·5, 2·2, 3·5, 4·3, and 5·0 mm. respectively; constriction at the top of the uppermost nummuloidal segments not preserved well enough for measurement.

Surface of shell with low, broad, transverse striæ, about nine in a length of 10 mm., and inclined to be obscure.

Discosorus, at present, is regarded as a cyrtoceroid genus of *Actinero-ceroids*. If that opinion be correct, then the Clay Cliff specimen here described is not a true *Discosorus*. Nor does it appear to be a true *Actino-ceras*, since the interior of the siphuncle preserves no trace of the calcareous deposits characteristic of that genus. In our present imperfect knowledge of the Clay Cliffs species, it is referred to *Actinoceras* solely because the siphuncle is strongly nummulitic and the conch appears to be straight.

Named in honour of Lawrence M. Lambe, palæontologist, Geological Survey, Canada.

Locality and Horizon. Clay cliffs, in the Meaford (No. 8545).

Maelonoceras (Beloitoceras) ligarius Billings
Plate XXXVIII, Figure 8; Plate XLI, Figure 2

Cyrtoceras ligarius Billings, Pal. Foss., Geol. Surv., Can., 1865, p. 176.

Specimen here described has a straight dorsal, and a convex ventral, outline, lengthwise curvature of the latter having a radius of 60 mm. A continuation of the lengthwise curvature of the ventral side of the specimen toward the aperture would result in the dorso-ventral constriction of the latter. No part of this living chamber is retained by the specimen. At least twelve septa present, eleven of these occupy a length of 50 mm., measured along the curvature of the ventral side of the conch. At the first clearly defined septum above the base of the specimen the dorso-ventral diameter of the conch is 29 mm.; at the uppermost septum it is 40 mm. Cross-section ovate, more obtusely curved on the dorsal side. Exact ratio of the lateral to the dorso-ventral diameter unknown. By Billings it was estimated as 36 to 40 at the top of the phragmacone. Expressing it in millimetres, the ratio appears to be nearer 32 to 40. Sutures of septa straight. Septa moderately concave. Traces may be detected of the siphuncle on the polished vertical dorso-ventral section of the specimen. Siphuncle appears to be moniliform, with oblique segments, whose ventral side reaches within 1 mm. of the ventral wall of the conch. Where the direct distance between successive septa is 3·5 mm., segments of siphuncle are 4·5 mm. long and nearly 3 mm. wide. In the vertical section, outline of these segments obliquely elliptical, with the longer axis directed lengthwise, to siphuncle.

Locality and Horizon. North point, Drummond island, in the Richmond formation (No. 2175).

In typical *Maelonoceras* the aperture is pear-shaped, with the sides of the hyponomic sinus sub-parallel. In the sub-genus *Beloitoceras*, typified by *Oncoceras pandion* Hall, the aperture is oval, with the ventral side more narrowly rounded.

Manitoulinoceras gen. nov.

The two species originally described by Billings from Clay cliffs, under the names *Cyrtoceras lysander* and *Cyrtoceras postumius* are relatively long and slender cyrtocones, distinctly depressed dorso-ventrally, and with a moniliform siphuncle close to the dorsal wall. They differ from *C. rebelle*, the type of the genus *Cyrtactinoceras*, in that, with increasing age, the sutures rise progressively upward from the dorsal toward the ventral side, instead of in the opposite direction. Also, at maturity the siphuncle does not migrate toward the centre of the conch, nor do its segments change from moniliform to cylindrical as in that species.

Cyrtoceras lysander is chosen as the genotype.

Manitoulinoceras makes its appearance in the Upper Mississippi valley as early as the Platteville at the base of the Black River formation. Here it is represented by *Cyrtoceras eugium* Hall, doubtfully by *Cyrtoceras neleum* Hall, from Beloit, Wisconsin, and more probably by the specimen figured by Clarke from the same locality under the name *Cyrtoceras neleum.* From the Platteville of Cannon Falls it is represented by *Cyrtoceras featherstonhaughi* Clarke. In the Tyrone member of the Black River, regarded as equivalent to the Platteville and Lowville, it is represented by an undescribed species from High Bridge, Kentucky, numbered 48329 in the collections of the U.S. National Museum.

Evidently *Manitoulinoceras* is another example of a Black River genus recurring in the Richmond.

Manitoulinoceras lysander Billings

Plate XLI, Figure 4 *a-f*

Cyrtoceras lysander Billings, Pal. Foss., 1, Geol. Surv., Can., 1865, p. 161, figs. 146 *a-d.*

Conch depressed dorso-ventrally; slowly enlarging; slightly curved lengthwise; ventral side convexly curved, and siphuncle located close to the ventral side.

Type Specimens. The specimen (No. 2177 *c*) used for figure 146 *a* accompanying the original description by Billings, is 41 mm. in length along the ventral outline. Dorso-ventral and lateral outlines 15 and 18 mm. respectively at the smaller end of the specimen, corresponding diameters at the larger end being 16 and 19·5 mm., indicating a distinct though small dorso-ventral depression, and a slow rate of enlargement lengthwise. The dorsal side of the conch has a radius of curvature of 82 mm., that of the ventral side being 105 mm., the curvature of the conch being slight.

There are thirty-one cameræ in this length of 41 mm., or sixteen in a length equal to the lateral diameter of the conch. Sutures almost straight, curving faintly downward on the lateral sides, resulting in scarcely perceptible lateral lobes. The sutures rise from the dorsal toward the ventral side, the angle increasing on approaching the upper end of the specimen. Septa only moderately concave.

Another specimen (2177 *g*) used by Billings for his figure 146 *c*, represents only that part which was polished in exposing the siphuncle. Segments of the siphuncle almost globular, width about 2 mm. where the septa are 2 mm. apart. Siphuncle almost in contact with the ventral wall.

A third specimen (No. 2177 *b*) retains the shell which is thin and black and crossed by fine, transverse striæ. Striæ almost parallel to the septa along the middle of the dorsal side; they rise along the lateral sides at an angle of about 15 to 20 degrees with the vertical axis, and are deflected slightly downward near the middle of the ventral side, thus locating the hyponomic sinus. In addition to the fine, transverse striæ, it is marked by faint, broad, longitudinal ridges which easily escape attention and which may not occur in other individuals.

In some specimens cross-section of conch is slightly more rapidly rounded on the ventral than on the dorsal side; in others, the relative convexity of the two sides is approximately the same. Ratio of the dorsoventral to the lateral diameter varies as the numbers 13 : 16, 13 : 17, 14 : 18, and 14·5 : 18·5.

Locality and Horizon. Clay cliffs, in the Meaford (No. 2177). Originally described from this locality.

Madison, Indiana, Specimen. *Cyrtoceracone* slightly curved lengthwise, depressed dorso-ventrally, siphuncle exogastric. Curvature of conch has radius of 150 to 175 mm. No marked difference noticed in curvature of dorsal and ventral sides, but they diverge slowly, from a dorso-ventral diameter of 15 mm. at the base of the specimen to 19 mm. at a point 46 mm. farther up, or at a rate of 9 mm. in 100 mm. The corresponding lateral diameters at points 46 mm. apart are 20 and 23 mm.

Dorsal side of the conch tends to be less convex or slightly flattened, the greatest curvature being along the dorso-lateral part of its contour. Ventral side distinctly more convex than the dorsal. Surface of the shell ornamented by numerous striæ approximately parallel to the sutures of the septa.

There are ten cameræ in a length of 16 mm. where the lateral diameter of the conch is 22 mm. Only the phragmacone is known.

The sutures rise from the dorsal toward the ventral side at an angle of 8 to 10 degrees with the horizontal. The concave curvature of the septa has a radius of 20 mm. dorso-ventrally and 25 mm. laterally.

Siphuncle in contact with ventral wall. When viewed directly from above, dorso-ventral diameter 3 mm. and lateral diameter 4 mm. When viewed from the lateral side the siphuncle has the appearance of very oblique segments, 1·5 mm. wide and 2 mm. long. Viewed from the ventral side, segments fusiform in outline, their maximum width being above mid-height, contraction at the top of the segments abrupt, but toward their base rate of contraction gradual. Along interior side, the vertical outline of the siphuncle resembles a succession of undulations of which the maxima are at mid-height of the cameræ, but owing to the obliquity of the latter near its contact with the ventral wall, the maxima of the undulations of the inner wall of the siphuncle are distinctly below the maxima of the more fusiform curvatures along the outer or ventral wall of the siphuncle.

From the Hitz layer at the top of the Saluda member of the Richmond formation, Madison, Indiana, U.S. National Museum.

Cyrtoceras tenuiseptum Faber[1] from some part of the Richmond, Waynesville, Ohio, and also from the Richmond, Versailles, Indiana, evidently is the same species as *Cyrtoceras lysander*.

In the U. S. National Museum there is a specimen from the Richmond numbered 48357, found loose in the creek at Waynesville. It widens from 7·5 mm. at its base to about 20 mm. at the top, in a length of 125 mm. Exact width at the top cannot be determined owing to a certain amount of flattening there. In its present condition its lengthwise curvature has a radius of 100 mm. near its base, changing to 150 mm. toward the top of the specimen. Along the middle of the specimen, ten cameræ occupy a length of 13 mm., the diameter here being about 18 mm.

Cyrtoceras irregulare Wetherby[2] from some part of the Richmond formation at Freeport, now, Oregonia, Ohio. This is a closely related form, differing apparently in having a relatively smaller number of cameræ in the same height, ten cameræ occupying a height of 24 mm. Siphuncle described as comparatively large, a statement not applicable to any of the forms here discussed.

Manitoulinoceras postumius Billings
Plate XLI, Figure 1

Cyrtoceras postumius Billings, Pal. Foss. 1, Geol. Surv., Can., 1865, p. 178.

Conch depressed dorso-ventrally; enlarging much more rapidly and curving much more strongly in a lengthwise direction than in *Cyrtoceras lysander* to the convexly curved ventral side. Siphuncle close.

Type Specimen. Specimen No. 2176, 68 mm. long, measured along the ventral outline. Only the lower part of the living chamber remains, 15 mm. in length. At its base dorso-ventral diameter 17 mm., and lateral diameter estimated at 20 mm. At the smaller end of the specimen dorso-ventral diameter 6 mm. Dorso-ventral apical angle about 12 degrees. The radius of curvature of the convex ventral side about 44 mm., the rate of curvature increasing slightly in an apical direction.

About eight cameræ occupy a length of 15 mm. measured along the siphuncle near mid-length of the specimen. At the top of the specimen eleven cameræ occupy a length equal to the lateral diameter of the conch, near mid-length of the phragmacone this number is nine, and at the base of the specimen it is eight. The sutures of the septa rise from the dorsal toward the ventral side. That this rise of the sutures increases toward the living chamber is indicated by the gradual change of the form of the segments of the siphuncle, from nearly globular to distinctly oblique, and more or less flattened vertically on passing from the lower part of the phragmacone toward the base of the living chamber.

Septa gently concave. Ventral side of siphuncle less than 0·5 mm. from the ventral wall. Along lower part of phragmacone segments of septa almost globular. Toward upper part of phragmacone these segments more crowded and more obliquely nummuloidal. Along the greater part of its length the diameter of the siphuncle is about 2 mm., but along its nummuloidal part the diameter of the segments, measured parallel to the septa, is 2·5 mm. Width of the contractions of the siphuncle at the septal necks about 1 mm.

[1] Jour. Cincinnati Soc. Nat. Hist., 9, 1866, p. 18, pl. 1, figs. 3 *a*, *b*, *c*.
[2] Jour. Cincinnati Soc. Nat. Hist., 4, 1881, p. 79, pl. 2, fig. 3.

Additional Specimens. Specimens of *Cyrtoceras postumius* are not common at Clay cliffs, but a few fragments may be found in any day's collecting. Unless more than one species is present among these fragments, there is considerable variation in the form of the cross-sections of the conch. Fragments whose dorso-ventral and lateral diameters are in the ratio of 8 to 10 appear to represent the average. Specimens occur in which this ratio is nearer 9 to 10. No specimens are known by the writer in which this ratio approaches 6·5 to 10, which is the ratio cited by Billings in his description of the type of this species.

The distance between the septa also is a variable quantity. In one specimen, three cameræ occupy a length of 5·5 mm. at a point where the dorso-ventral diameter is 14 mm.; 20 mm. farther up, near the living chamber, three cameræ occupy a length of scarcely 4 mm. In one specimen having a dorso-ventral diameter of 15 mm. at the larger end, there are fourteen cameræ in a length of 28 mm. measured along the ventral outline of the conch.

Traces of low, flat, transverse striations are found on several specimens as in *Cyrtoceras lysander*.

This species is regarded as closely related to *C. lysander*, described from the same locality. It agrees with the latter in the dorso-ventral depression of the conch, in the globular form of the segments of the siphuncle in all except the later stages of growth of the conch, in the increased rise of the sutures of the septa toward the ventral side at later stages of growth, in the relatively short cameræ, and in the character of the transverse surface striæ. It differs from the latter chiefly in its greater curvature and in its more rapid rate of enlargement.

Locality and Horizon. Clay cliffs, in the Meaford (No. 2176, the type; No. 8543). Originally described from this locality.

Zitteloceras hitzi Foerste

Plate XLI, Figure 3 *a*, *b*

Cyrtoceras hitzi Foerste, Bull. Sci. Lab. Denison Univ., 16, 1910, p. 78, pl. 1, figs. 7 A, B; pl. 2, figs. 23 A-C.

Zitteloceras hitzi Foerste, Jour. Cincinnati Soc. Nat. Hist., 22, 1917, p. 51.

Specimen about 32 mm. in length, measured along the outer or convex curvature of the conch; this curvature has a radius of 19 mm. Cross-section circular. The diameter, 4 mm. below the top, is 9 mm., diminishing to 2·2 mm. at the base. Apical angle about 15 degrees. At the top of the specimen septa moderately concave.

Surface traversed by sharply elevated transverse striæ, which are directly transverse or curve only slightly downward on the dorsal and lateral sides of the conch, but which, along the median line of the ventral side, curve strongly but narrowly downward into a V-shaped lobe, rounded at its lower end. This lobe locates the former position of the hyponomic sinus. In a length of 5 mm. at the top of the specimen there occur eight transverse striæ; thirteen at mid-length, fourteen at the base of the specimen. Near the top of the specimen, the grooves between the striæ are flattened and are wider than the striæ, especially along the ventral side of the shell.

Range. Originally described from the Hitz layer at the top of the Saluda division of the Whitewater member of the Richmond formation, at Madison, Indiana.

The frilling of the sharply raised transverse striæ may be detected in the type of the species, but is very moderate in amount.

Locality and Horizon. A mile and a half southwest of Kagawong, in the Kagawong (No. 8544).

A similar form is listed[1] under *Cyrtoceras* (*Cyrtorhizoceras* ?) *kagawongensis.* Apparently the Kagawong specimen is much larger than the type from Madison, Indiana, but no other difference is noted at present (Plate XLI, figure 3).

Zitteloceras makes its first appearance in the upper or Leray division of the Lowville, on Allumette island, Ottawa river, Canada, where it is represented by *Z. billingsi* (Salter). At about the same horizon at Beloit, Wisconsin, it is represented by *Z. beloitense* sp. nov. in the Platteville member of the Black River formation. The type of this species was one of the two specimens used by Hall as types of his species *Cyrtoceras neleum*, and is the specimen figured by Whitfield[2] under the name *Cyrtoceras tenuistriatum.* Whitfield chose as the type of *Cyrtoceras neleum*[3] the larger of the two specimens used by Hall, in which the writer agrees with him. A third species is *Zitteloceras hallianum*, from the Trenton at Middleville, New York. To a fourth species[4] originally described under *Cyrtoceras hallianus*, from the Platteville at Janesville, Wisconsin, the name *Zitteloceras clarkeanum* was given.[5]

Zitteloceras, therefore, is one of the numerous Black River genera which recur in the Richmond.

Oncoceras pauper sp. nov.
Plate XLI, Figure 5 *a*, *b*

Specimen 40 mm. long; laterally compressed, dorso-ventral diameter 20 mm. in length, lateral diameter 18 mm. in length, at the base of the living chamber. Ventral side fairly evenly convex lengthwise, with a radius of curvature of 35 mm. Along the more gibbous part of the dorsal side, radius of curvature about 65 mm.; gibbous part about 25 mm. in length, and both above and below it dorsal outline of the conch more or less distinctly concave lengthwise. Sixteen millimetres above the base of the living chamber, the dorso-ventral diameter of the latter has diminished to 16 mm., due to the inward curvature of the dorsal side. The living chamber also is contracted laterally; 16 mm. above its base, the lateral diameter is estimated at about 14 mm., the specimen being fairly well preserved on one side of this chamber. Aperture not preserved.

Ten cameræ present, upper four occupy a total length of 10 mm. along the ventral side; the next five also occupy a length of 10 mm. Sutures almost directly transverse. Lowest septum only slightly concave; septum at the base of the living chamber has a radius of curvature of concavity of 11 mm. Siphuncle between 4 and 5 mm. toward the left of the plane

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[1] "Upper Ordovician Formations in Ontario and Quebec," Mem. 83, Geol. Surv., Can., 1916, p. 108.
[2] Mem. Am. Mus. Nat. Hist., 1, pt. 2, 1895, pl. 9, fig. 12.
[3] Ibid., pl. 9, figs. 10, 11.
[4] Geol. Minnesota, 3, pt. 2, p. 805, pl. 60, figs. 11, 12.
[5] Jour. Cincinnati Soc. Nat. Hist., 22, 1917, p. 52.

of symmetry, on the ventral side. Where the septa are slightly over 2 mm. apart, maximum diameter of the segments of the siphuncle within the cameræ 1·5 mm., contracting to slightly over 1 mm. at the septal necks, producing a moniliform appearance. Surface of the shell transversely striated by poorly preserved striæ.

Locality and Horizon. Clay cliffs, in the Meaford (No. 8542).

Oncoceras is first cited from the Chazyan (Valcour) of New York, where it is represented by *O. pristinum* Ruedemann. It is represented by *O. douglassi* Clarke in the Prosser member of the Trenton, in Minnesota. Typical specimens, of an undescribed species, occur in the Trenton at Kelso, Lincoln county, Tenn. The genotype, O. *constrictum*, occurs in the Trenton of New York. A rather elongate form, also undescribed, occurs in the Catheys, 2 miles east of Mowd, Maury county, Tenn.

The occurrence of *Oncoceras* in the Richmond is another instance of a Black River or Trenton genus recurring in Richmond strata.

In a recent paper[1] Ruedemann has regarded it as possible to recognize sex characters in the specimens of *O. pupæforme* Ruedemann, occurring in the upper Utica shale at Holland Patent, New York. Here the conchs with relatively straight phragmacones, strongly humped just below the living chamber on its ventral side, are regarded as mature males; and the larger specimens with more evenly curved conchs are regarded as the females.

Cryptolithus tesselatus Green

Plate XLV, Figure 16 *a*, *b*

Cryptolithus tesselatus Green, Mon. Tril. N. Amer., 1832, p. 73, cast 38, pl. 1, fig. 4.

Trinucleus concentricus Hall, Pal. New York, 1, 1847, p. 249, pl. 65, figs. 4*a*, 4*c*.

Trinucleus concentricus Weller, 1903, Geol. Surv., New Jersey, Pal. 3, p. 192, pl. 14, figs. 3, 4.

Cephalon strongly convex, pitted border along its lateral margins inclining downward, both glabella and cheeks being prominently convex, especially on anterior view. Nuchal spine short and blunt. Surface smooth.

Location and Horizon. Originally described from Waterford, New York, where it occurs in the lower Trenton, in the Snake Hill beds, common in the overlying Canajoharie shale, in the middle Trenton, and probably ranging to the top of the Trenton. It is probably restricted to the Trenton, the forms frequently cited from strata above the Trenton belonging in part to *C. bellulus* Ulrich, and *C. recurvus* Ulrich, or to other species not yet differentiated. Some of the Trenton forms, at present cited under *C. tesselatus*, may belong to distinct species. Typical representatives of *C. tesselatus* apparently range in the lower or Trenton part of the Martinsburg shale as far south as Pennsylvania, New Jersey, Maryland, and Virginia. The New Jersey specimens figured by Weller are regarded as typical in character. Those specimens of *Cryptolithus* which occur in the Trenton of Kentucky and of Oklahoma need further study before their specific identity with *C. tesselatus* can be regarded as established.

[1] "On Sex Distinction in Fossil Cephalopods," New York State Mus. Bull., Nos. 227, 228, 1921, p. 68.

Cryptolithus sp.

Plate XLIII, Figure 17

Cephalon here described 6 mm. long, exclusive of the posterior nuchal spine, and 14 mm. wide. Glabella obovate, 3·5 mm. wide, one-third of its length from its anterior end, separated by a sharply-defined furrow from the nuchal segment of the cephalon. The nuchal segment has a triangular outline, terminating posteriorly in a short spine, the length from the nuchal furrow to the tip of the spine being 1·2 mm. Glabella strongly, almost bulbously convex, especially anteriorly where it rises almost 2 mm. above the brim. Corresponding elevation of the cheeks nearer 1·2 mm. Anterior to the centre of the glabella are three rows of pits. Anterior to the lateral sides of the glabella and the anterior end of the cheeks there are four rows. In some specimens only two pits are found directly in front of the middle of the glabella, and three pits laterally. An additional row appears one-third of the distance from the anterior angle toward the postero-lateral one, and additional pits appear at the latter angle but more irregularly arranged. The pits forming the first two rows are arranged along radii centring at the nuchal groove along the median line of the cephalon. These two rows are separated from the remainder by a slightly more elevated ridge. The remaining pits alternate more or less distinctly. The brim curves strongly downward, especially postero-laterally, as far as the second row of pits, but curves outward at the first row, beyond which the sharply elevated border slopes abruptly downward. Posterior margin of the cephalon almost directly transverse for one-third of the distance from the dorsal furrow to the genal angle, then curving distinctly backward. One specimen retains a genal spine, directed straight backward, but its entire length cannot be determined.

Pygidium 3·5 mm. long and 12 mm. wide; median lobe 2·3 mm. wide; anterior margin straight and posterior margin slightly angulate at the centre. The blunt posterior margin of median lobe reaches the posterior margin of the cephalon; it bears traces of eleven transverse rings with room for two or three more; posterior rings very obscure; all the rings much more distinctly defined on casts of the lower surface. Anterior four lateral ribs of the pygidium distinctly defined, especially anteriorly where the margin rises abruptly and is defined by a narrow groove immediately posterior to this margin. In addition to the well-defined lateral ribs there are two or three poorly-defined ones.

Surface of the glabella and of the fixed cheeks marked by very minute pits, visible only under a magnifier when using cross-illumination. Similar minute pits are seen on casts of the lower surface.

Locality and Horizon. From Montmorency falls, near Quebec, Canada; No. 1773, collected by W. E. Logan. From Montreal; No. 1753, cephalon; No. 1753 *a*, pygidium; collected by W. E. Logan. From the Trenton.

Cryptolithus lorettensis sp. nov.

Plate XLIII, Figures 15, 16

Brim of cephalon with three rows of pits anterior to the middle of the cephalon, and with four rows anterior to the antero-lateral parts of the glabella and the anterior half of the cheeks. No trace of elevated ridge limiting anterior two rows from those farther back. Pits of all four rows arranged along radii centring along the median part of the posterior margin of the cephalon. Both the surface of the glabella and cheeks and casts of their lower surface rather strongly pitted, giving these surfaces a reticulate appearance. Otherwise apparently as in the specimens described from Montmorency falls and Montreal.

Locality and Horizon. From the falls of Lorette, near Quebec, Canada. Collected by W. R. Billings. From the Trenton.

Cryptolithus bellulus (Ulrich)

Plate XLV, Figure 17; Plate XLIII, Figures 19, 20

Trinucleus bellulus Ulrich, 1878, Jour. Cincinnati Soc. Nat. Hist., 1, p. 99, pl. 4, fig. 15.

Cryptolithus bellulus Bassler, 1919, Maryland Geol. Surv., Cambrian and Ordovician, p. 333, pl. 56, figs. 5, 6.

Cephalon short but broad, length equalling one-fourth of width. Glabella rather narrowly obovate; two-elevenths or two-twelfths of width of cephalon, and two-thirds of maximum width of cheeks. Anterior extends strongly in advance of cheeks, and posterior end extends farther backward, the groove limiting the neck-ring being faint and curving strongly backward. The neck-ring terminates abruptly in a very slender spine, 2·5 mm. in length, in a glabella whose length anterior to the spine is 10 mm. Posterior margin of the cephalon almost straight, curving slightly backward toward the genal angles. Groove limiting the posterior border from the cheeks distinctly defined. None of the specimens at hand preserve the genal spines. Middle third of anterior margin of cephalon almost straight or shows a slight tendency toward angularity anterior to the middle of the glabella. Compared with other species, entire cephalon remarkably low and flat. Neither the glabella nor the fixed cheeks as strongly convex as in *C. tesselatus*, pitted brim flattish and almost horizontal in position. Pits forming the two outer rows of the brim conspicuously larger, tending to be arranged radially, with the posterior end of the glabella at the centre of the radii. The pits of the inner rows alternate in position. Immediately anterior to the centre of the glabella are three rows of pits. On each side of the glabella and anterior to the cheeks are four rows of pits. A fifth row of pits begins half-way between the anterior end of the cheeks and their postero-lateral margin, and in the furrow between the posterior margin of the cheeks and the posterior border of the cephalon there are additional pits.

Pygidia very short, but broad. In a pygidium 10 mm. wide the length is 3 mm. In this specimen the anterior part of the median lobe is 2·7 mm. wide and its blunt posterior end reaches the posterior border of the pygidium. Number of rings on this lobe nine or ten; all are low. Lateral lobes of the pygidium low and flat, and distinctly below the level of the median lobe, crossed by three very faint grooves, limiting the lateral ribs of the pygidium.

Locality and Horizon. The cephalons here described are from Yamaska river, 1½ miles below St. Hugues, associated with *Triarthrus eatoni* and *Leptæna moniquensis*. The pygidia here described are from Yamaska river at St. Hyacinthe, between the railway bridge and the dam, associated with the same fossils. The same association is observed on Nicolet river. The horizon is the *Cryptolithus* zone at the base of the Lorraine.

C. bellulus was described from the Eden shale at Covington, Ky., from the lower or Economy member. It has been identified by Bassler from the vicinity of McConnellsburg, and by Ruedemann from the Indian Ladder beds in eastern New York.

In *C. recurvus* Ulrich, also from the Eden shale at Covington, Ky., and from near McConnellsburg, Pa., the posterior margin of the cephalon curves much more strongly backward laterally, and both the glabella and cheeks are finely punctate.

Distribution of Cryptolithus bellulus in Canada. In addition to the localities at St. Hugues, St. Hyacinthe, and on Nicolet river *C. bellulus* occurs at the same horizon, at Breault, Petite Caroline, and elsewhere in Quebec. In the Don Valley brick-yard, it occurs associated with *Leptæna moniquensis.*

The *Cryptolithus* occurring in the lower part of the Sheguiandah clay shale, 25 feet above the level of the lake, on Workman brook, southeast of Meaford, is regarded as belonging to the same species.

Pulaski Specimens of Cryptolithus. In the upper or Pulaski division of the Lorraine of New York *Cryptolithus* is common except at the extreme top of the *Pholadomorpha pholadiformis* zone, from which it is absent.

At the *Rafinesquina pulaskiensis* zone, west of the bridge 1 mile east of Pulaski, New York, specimens of *Cryptolithus* occur which resemble *C. bellulus* in the long, acicular spine terminating the nuchal segment posterior to the glabella, and in the number and arrangement of the pits on the broad brim. The cephalon, however, is relatively longer, narrower, and more convex, and posterior border of the cephalon curves more strongly backward toward the postero-lateral angles. Two pits occur on each side of the cast of the lower surface of the posterior end of the median lobe, one at the anterior margin of the distinct nuchal furrow, a short distance above the level of the dorsal furrow; the other pit at the posterior margin of this nuchal furrow. These pits are remnants of former segmentation of the glabella. Immediately anterior to the nuchal furrow the posterior margin of the glabella is slightly ridged transversely.

Cryptolithus recurvus Ulrich

Plate XLV, Figure 12 *a, b;* Plate XLIII, Figure 18

Cryptolithus recurvus Ulrich, Maryland Geol. Surv., Cambrian and Ordovician, 1919, p. 334, pl. 56, figs. 14-17.

"*Cryptolithus recurvus* differs from the Trenton form usually identified as *Cryptolithus tesselatus* Green or *Trinucleus concentricus* Hall by the great width and decided posterior recurvance of the border and by its steeper slope, the cephalon as a whole being, therefore, more convex. *C. concentricus* resembles it in the last respect, but its border is of less width and has fewer rows of pits. Among the differences distinguishing the species from all American species of the genus is the finely punctate and not reticulate marking of the glabella and lateral lobes.

"The type specimens figured were collected in the Eden shale at Covington, Kentucky, and in the uppermost Trenton limestone at the same place." (Bassler, 1919.)

It occurs also in the Eden division of the Martinsburg shale at Jordans Knob, 1½ miles northeast of Fort Loudon, Pa.

The specimen here figured from the *Cryptolithus* zone on Nicolet river may belong to this form. At least, the posterior margin of the cephalon curves strongly backward toward the genal angles, and the nuchal spine appears to be short. It was obtained from layer B, 157 feet below the highest level containing *Cryptolithus*.

Triarthrus becki Green
Plate XLIII, Figure 22

Triarthrus beckii Green, Mon. Tril. North Amer., 1832, p. 87, cast 34, pl. 1, fig. 6.
Paradoxides beckii Hall, Amer. Jour. Sci., 33, 1838, p. 142, fig. 1.
Triarthrus becki Bassler, Cambrian and Ordovician, Geol. Surv., Maryland, 1919, p. 342, pl. 56, figs. 7-13.

Specimens relatively low and flat. Genal angles rounded, cut in such a manner by the facial sutures that both free and fixed cheeks meet at these angles. Glabella low and broad, with the two posterior pairs of glabellar furrows distinctly outlined along their full lengths; the two anterior pairs are indicated only along their proximal halves.

Ruedemann, in an unpublished manuscript on the Lorraine faunas of New York, notes the following characteristics distinguishing *T. becki* from *T. eatoni*. Surface of cranidium distinctly more convex; the outline of the cranidium distinctly convex laterally as well as anteriorly; the width of outline scarcely exceeds that of a semicircle. Glabella somewhat broader than long. Frontal lobe of glabella distinctly shorter than in *T. eatoni*. Dorsal furrows not parallel, as in the latter species, but converging distinctly toward the front, producing a less subrectangular but more rounded anterior outline, especially at the antero-lateral angles and directly in front of the middle of the glabella. Glabellar furrows less oblique, forming angles of about 20 degrees with directly transverse lines, in place of 30 degrees as in *T. eatoni*. Fixed cheeks large, contraction taking place farther toward the front, at the first pair of glabellar furrows, instead of opposite the second pair as in *T. eatoni*. Palpebral lobes distinctly shorter, and eyes probably smaller. Mucronate nodules on the posterior margin of the segments of the axis of the thorax thicker and a little longer, overlapping slightly. Corresponding to the relatively broader glabella and the broader head, the body also is relatively broader than in *T. eatoni*.

According to Ruedemann, *T. becki* is related more nearly to certain European species of *Triarthrus* occurring in Sweden and in Great Britain than to *T. eatoni*, thus suggesting the North Atlantic affinities of *T. becki*, whereas *T. eatoni* is of more southern distribution.

Locality and Horizon. *T. becki* was described originally from the Snake Hill shale at Cahoes in New York, in the eastern basin of the Trenton. It entered Mohawk valley during Canajoharie time and continued during

Schenectady time, but is not found in the Indian Ladder beds. It ranges northward into the Champlain valley, in eastern New York and in Vermont. Southward it occurs in corresponding parts of the Martinsburg shale in Pennsylvania and Maryland. It does not occur in Utica or overlying strata.

Triarthrus eatoni (Hall)
Plate XLV, Figure 13

Paradoxides eatoni Hall, Am. Jour. Sci., 33, 1838, p. 142, fig. 2.

Original Description. "Buckler convexly curved on the front margin, with a concave curvature laterally, nearly flat; lateral lobes broader posteriorly, greatest width about one-half the breadth of the middle lobe, abruptly diminishing in breadth and much less than half their greatest breadth opposite the centre of the middle lobe; middle lobe somewhat longer than broad, nearly flat; sulci distinct, with the intermediate portions scarcely convex.

"This species is abundant in the greywacke slate in Turin, Utica, Fort Plain, and elsewhere in the state of New York."

To this description may be added the statement that the glabella is distinctly longer than wide. Posterior half of the neck segment and of each of the thoracic segments marked along the median line by a sharp, narrow ridge, terminating posteriorly in a distinct short point or spinose nodule.

According to Ruedemann, who recently has made a special study of this species, in connexion with his still unpublished work on the Lorraine of New York, *T. eatoni* is characterized by "the more elongate shape of the glabella, the more oblique direction of the glabellar furrows, the subparallel direction of the dorsal furrows, the more squarish frontal outline of the glabella, and the more abrupt and more posteriorly situated contraction of the fixed cheeks. As a result of this direction of the suture, the eyes in *T. eatoni* are placed farther back and more inward, and the fixed cheeks are narrower than in *T. becki*."

Locality and Horizon. According to Ruedemann, *T. eatoni* makes its first appearance as a rare fossil in the Trenton limestone at Middleville, New York.

It is known, also, in the Frankfort shale, but attains its largest size and maximum development in the Utica. It ranges throughout the Economy zone of the Lorraine, and probably continued to the end of the Southgate zone. "The *Triarthrus* of the Canadian Gloucester shale is a true *T. eatoni*, whereas that of the Collingwood shale at Collingwood, Ontario, represents a mutation that still shows some approach to the earlier *T. becki* in the subequal length and width of the glabella and the course of the facial sutures."

Triarthrus occurs south of Little Current, in the lower part of the Sheguiandah shale; the form occurring here probably belongs to *T. eatoni*.

The specimens of *Triarthrus* occurring in the *Cryptolithus* zone in the Nicolet River section are closely related to *T. eatoni*, but are described in the following section as a distinct species.

Triarthrus huguesensis sp. nov.
Plate XLIII, Figure 21

Cranidia usually not exceeding 5 or 6 mm. in length. Nuchal and glabellar grooves as in *Triarthus eatoni*, but more sharply incised, at least on casts of the lower surface. Cranidia more convex. The chief differences are presented by the facial sutures. Palpebral lobes more strongly defined and extending backward to a point half-way between the posterior pair of glabellar grooves and the nuchal groove; they diverge less posteriorly from the dorsal groove of the cranidium. Posterior to the palpebral lobes the fixed cheeks appear narrower, equalling less than half the width of the glabella instead of exceeding half the width as in typical *T. eatoni*. There is a minute granule along the median line of the nuchal segment.

Locality and Horizon. On Yamaska river 1½ miles below the landing at St. Hugues. Also at St. Hyacinthe, on Yamaska river, and on Nicolet river. At Breault it occurs on Bécancour river. In the *Cryptolithus* zone of the Lorraine.

Isotelus gigas DeKay
Plate XLIV, Figure 6

Isotelus gigas Dekay, Ann. Lyceum Nat. Hist. New York, 1, 1824, p. 176, pl. 12, fig. 1; pl. 13, fig. 1.
Isotelus gigas Bassler, Cambrian and Ordovician, Geol. Surv., Maryland, 1919, p. 344, pl. 48, figs. 23-25.

"Outline of an entire individual subelliptical, with the anterior and posterior extremities somewhat pointed; the trilobation nearly obsolete. Head subtriangular to semi-elliptical in outline, convex, slightly flattened in front; the anterior margin rather sharply rounded; facial sutures meeting at an angle, at or just benind the frontal margin, from this point they describe a broad, subarcuate curve, and after passing around the eyes they curve outward and then downward, intersecting the posterior margin at some distance outside the eyes; glabella obscurely defined and more obscurely lobed; occipital furrow and segment obsolete; free cheeks marked by an intramarginal furrow, above which their general surface is elevated into a more or less conspicuous node, crowned by the eye. Thorax with a broad axial lobe, occupying more than one-third the width, consisting of eight segments. Pygidium subtriangular in outline of nearly the same size and shape as the head, its lobation very obscure, especially in the larger individuals, the dorsal furrows being hardly distinguishable; axis much narrower at its anterior extremity than the axis of the thorax, tapering rapidly to the obtusely rounded posterior extremity, which lies at about one-fourth the length of the pygidium from the posterior margin; pleuræ convex, smooth in the larger individuals, but in younger ones marked by about ten obscure segments, which also continue across the axis; the entire margin of the pygidium, except where it joins the thorax, bordered by a rather broad, slightly depressed, marginal border; the antero-lateral angles bent abruptly downward."[1]

([1] Weller, in Pal. New Jersey, 3, 1903, p. 192.)

Locality and Horizon. Described originally from the Trenton Falls area of New York, but occurring also in the Trenton, of Pennsylvania, Maryland, and Virginia.

Isotelus gigas, though frequently identified from Cincinnatian strata, is not known above the Trenton.

Canadian Occurrences of Isotelus. Species of Isotelus occur in the *Proetus* zone of the Lorraine, in the Nicolet River section and at Hawthorne. In the *Pholadomorpha* zone they occur in the Nicolet River section and at St. Hilaire, in the Waynesville on Snake island, a mile west of Vars, at Streetsville, and at Clay cliffs. In the Kagawong, it occurs west of Gore Bay. At all of these Canadian localities *Isotelus* has been a rare fossil, and not enough material has been collected to identify the species with accuracy. Hence the following descriptions of species from other areas are added as those of species most likely to occur in Canadian representatives of the Cincinnatian.

Isotelus megistos Locke
Plate XLIV, Figure 5

Isotelus megistos Locke, Amer. Jour. Sci., 42, 1842, p. 366, pl. 3, fig. 9.
Isotelus megistos Bassler, Cambrian and Ordovician, Geol. Surv., Maryland, 1919, p. 343, pl. 58, figs. 10, 11.

Both spinous (male ?) and aspinous (female ?) forms of this species occur. Compared with *Isotelus maximus,* the base of the spine is much wider and spine tapers much more rapidly; the hypostoma shows coarser venations, the inner edges of the limb are straighter, and the hypostoma as a whole relatively longer (Bassler).

Locality and Horizon. Described from the upper or McMillan division of the Maysville at Cincinnati, Ohio. Occurring at the same horizon in Maryland, Pennsylvania, and Tennessee.

Isotelus maximus Locke
Plate XLIV, Figure 7

Isotelus maximus Locke, 2nd Ann. Rept. Geol. Surv., Ohio, 1838, p. 246, figs. 8, 9.
Isotelus maximus Foerste, Bull. Sci. Lab. Denison Univ., 19, 1919, p. 98, pl. 17, figs. 1, 2.
Cf. *Isotelus brachycephalus* Foerste, ibid., pls. 14, 15.

Compared with *I. megistos, I. brachycephalus* is short and broad, this distinction being characteristic of all three parts of the carapace, the cranidium, thorax, and pygidium. It occurs in the Liberty formation and apparently also in the upper part of the Waynesville in various parts of Ohio, Indiana, and Kentucky. No attempt has been made as yet to determine definitely either its vertical or its geographical range.

I. maximus, described from the Liberty formation, Adams county, Ohio, may be the same thing, but the more complete pygidium figured by Locke appears to be more elongate than in typical *I. brachycephalus.* A pygidium of the more elongate type occurs in the Meaford at Manitowaning.

Homotelus stegops (Green)
Plate XLIV, Figure 4

Isotelus stegops Green, Monograph Trilobites North America, 1832, p. 71, cast 26, 27.
Isotelus stegops Bassler, Cambrian and Ordovician, Geol. Surv., Maryland, 1919, p. 342, pl. 56, figs. 3, 4.

"Compared with *Isotelus maximus* Locke, which *I. stegops* most closely resembles, the Eden form has the eye farther forward, smaller spines, and the flattened border, especially of the pygidium, less distinct" (Bassler).

In well-preserved specimens the marginal part of the pygidium curves downward without any strongly-defined marginal depression as in typical *Isotelus*. The absence of this distinct marginal depression or groove is one of the most characteristic features of the new genus *Homotelus* proposed by Raymond.

Proetus chambliensis Foerste
Plate XLVI, Figure 7

Proetus chambliensis Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 320, pl. 4, figs. 1 A-H.

Small trilobites, with large, free cheeks, and with long eyes placed close to the glabella. Glabella oblong, with only faint traces of glabellar furrows. Specimen under a strong lens shows minute transverse striations, as in *Proetus undulostriatus*.

One of the type specimens is 14·5 mm. long, of which nearly 5 mm. belongs to the cephalon, 5 ·5 mm. to the thorax, and 4 mm. to the pygidium. Distance from anterior outline of cephalon to a line connecting the posterior tips of genal spines 7·5 mm. Distance between these tips exceeds 10 mm. Width of the anterior part of the thorax about 9 mm. For about six segments width of thorax is about the same, but it becomes narrower posteriorly. Width of pygidium about 6 mm.

Width of posterior part of glabella about 3·5 mm. Length of glabella, as far as nuchal groove, 3 mm. As in other species of *Proetus*, the glabella is slightly enlarged posteriorly, where it adjoins the concave curvature of the large palpebral lobes. A short, faint groove, scarcely 1 mm. in length, starts opposite the middle of the palpebral lobe and extends diagonally backward, limiting the anterior part of the posterior pair of lateral glabellar lobes. A second, fainter groove extends diagonally inward and moderately backward from about the anterior edge of the raised rim of the palpebral lobe. Distance from a line connecting the lateral terminations of this second pair of grooves to the anterior edge of the glabella 1 mm. A third, still shorter and fainter, pair of grooves is found anterior to the second pair and is scarcely visible.

The facial suture starts slightly exterior to a point directly in front of the palpebral lobe, curves diagonally inward, apparently follows the outer edge of the palpebral lobe just below the visual surface, and posteriorly bends outward again at an angle of about 45 degrees with a directly transverse line, cutting the posterior margin of the cephalon within 1·5 mm. of the longitudinal furrow limiting the axial lobe of the thorax, and an equal distance from the groove limiting the inner edge of the lateral border of the cephalon at the genal angle. Visual surface smooth and with a lunate form.

At genal angle the marginal border of the free cheek has a width of about 0·8 mm. Length of genal spine 2·5 mm., in the type specimen here described, but in a larger specimen on the same rock fragment it equals 3·5 mm.

Anteriorly, glabella distinctly defined, and separated from marginal border of cephalon by a narrow space about equalling the width of the border, the two together equalling about 0·8 mm.

The axial lobe of the thorax has a width of fully 3·5 mm., narrowing to 2·5 mm. at the anterior end of the pygidium.

Pleural segments ten. A median groove follows the lateral lobes of these segments laterally to the point where they curve posteriorly. Length of this posteriorly directed part approximately between 1 and 1·5 mm.

Axial lobe of the pygidium distinctly defined posteriorly as well as laterally. Length 2·8 mm. in a pygidium whose length is 3·8 mm., the flattened marginal border of the pygidium having a width of 1 mm. Essentially the same width of border is shown posteriorly by pygidia which have a length of nearly 5 mm.

Anterior annulation of axial lobe of pygidium, in contact with the thorax, relatively narrow but strongly defined. The second annulation is the first one completely exposed, and always is very distinct. It is followed by one fairly distinct annulation, three much less distinct, and rarely by another scarcely perceptible annulation, the last being followed by a space having room for two more annulations.

On the lateral lobes of the pygidium the anterior pleural segment, adjoining the pleural segments of the thorax, strongly marked posteriorly. The next pleural segment is the first one completely exposed; it is fairly distinct, and has an indication of a median groove. It is followed by two much less distinct segments with no trace of a median groove, followed by another, scarcely perceptible segment. The first completely exposed pleural segment extends across the flattened border of the pygidium. The remainder scarcely affect the border. Flattened border of pygidium relatively broad and slightly concave.

P. parviusculus Hall was described from Cincinnati, Ohio, where it is listed from the Corryville member of the Maysville formation. Glabella rotund oval, without visible location. Border of the cephalon broad and flat, even anteriorly, and defined from the remainder of the cephalon by its more nearly horizontal slope as well as by the shallow groove; there is no additional narrow elevation along the margin of the border. Thoracic segments comparatively prominent. Pygidium with prominent axis, and flat lateral lobes having a plain expanded border; lateral lobes with about four indicated segments, becoming indistinct posteriorly, the first two with longitudinal furrows.

In *P. chambliensis* the glabella is relatively longer and more oblong oval in outline. It presents not only fairly distinct indications of the large basal lobes, but also indications of the middle pair, the limiting furrows being readily distinguishable under a lens. Along the outer margin of the flat border of the cephalon is a very narrow elevated line, becoming broader and more prominent just before reaching the anterior part of the facial suture, which gives rise to the strongly-defined marginal elevation of the cephalon at the edge of the border anterior to the glabella. Eyes relatively longer and more closely appressed to the glabella. Thoracic segments less prominent, especially along the axial lobe. The axial lobe of the pygidium rises strongly above the very moderately convex lateral lobes, and only the anterior segments are distinctly indicated.

Although unquestionably closely related to *P. parviusculus*, it seems possible to distinguish *P. chambliensis* from the Cincinnati species by means of the differences indicated.

Locality and Horizon. Found in the *Proetus* zone of the Lorraine on Nicolet river, and at the same horizon at Chambly Canton, the mouth of Huron river, and also at Vars and Hawthorne. Originally described from Chambly Canton.

Odontopleura sp.

The so-called species of *Acidaspis* listed from the *Proetus* zone at Vars and Hawthorne, probably belong to *Odontopleura*, though *Ceratocephala* also occurs in the Ordovician of America. The specimens found were recorded as *Acidaspis* when collected, and probably have been lost, their state of preservation being poor.

Calymene senaria Conrad

Calymene senaria Clarke, Geol. Minnesota, 3, pt. 2, 1894, p. 700, fig. 3.
Calymene senaria Foerste, Bull. Denison Univ., 14, 1910, pl. 2, fig. 14.

This species is characterized by the subtriangular outline of the cephalon, that part of the border directly in front of the glabella protruding strongly forward instead of being bent upward at a conspicuous angle, as in *Calymene meeki*, and most other Ordovician species of *Calymene*. Genal angles acute and directed strongly backward. Lateral ribs on the pygidium furrowed conspicuously along their median line their entire length, excepting occasionally along their inner ends, near the furrow separating the axis from the lateral parts of the pygidium.

Locality and Horizon. This type of *Calymene* is characteristic of the Trenton formation in New York and neighbouring states and is unknown in Cincinnatian strata or their equivalents.

Calymene conradi Emmons

Calymene conradi Emmons, Amer. Geol., 1, pt. 2, 1855, p. 236.
Calymene conradi Foerste, Bull. Denison Univ., 17, 1914, p. 320.

This species was described by Emmons in the following terms:

Small, wide across the cheeks; cheek angles obtuse or rounded; posterior lobes of the glabella comparatively large and globular; thoracic lobes very convex, with a row of tubercles in the furrow or between the axis and the lateral lobes. Lorraine shales.

Since this species was described nine years later than volume 1 of the "Paleontology of New York," Emmons probably attempted in his description to differentiate the Lorraine form from the Trenton and other forms described and figured by Hall. If so, he was not very successful. The only diagnostic character he mentioned is that the cheek angles were obtuse or rounded, and this character the writer has not been able to verify since it has not been possible to secure specimens retaining the genal angle. Apparently the posterior pair of lobes does not differ in size and form from those in other upper Ordovician species. Only two differences have been noted, and even these may not be characteristic of the species as a whole. Dorsal furrows, between the two posterior pairs of lobes and the fixed cheeks, remarkably narrow and sharply incised in several specimens, and in one complete specimen, about 26 mm. long, the lateral ribs are narrow and show no evidence of a median furrow until near the marginal border of the pygidium where they widen. The anterior three show a faint, median depression. The row of tubercles in the dorsal furrows between the axis and the lateral lobes, seen on casts of the lower surface, do not differ diagnostically from similar casts in other *Calymenidæ*.

Calymene granulosa Foerste
Plate XLIV, Figure 1 *a*, *b*

Calymene callicephala granulosa Foerste, Bull. Sci. Lab. Denison Univ., 14, 1909, p. 294.
Calymene granulosa Bassler, Cambrian and Ordovician, Geol. Surv., Maryland, 1919, p. 356, pl. 56, figs. 1, 2.

Size relatively small. Anterior border of cephalon less abruptly elevated than in *Calymene meeki*. Surface covered by numerous granules larger and more conspicuous than those of the latter species.

Locality and Horizon. Sheguiandah road, 3 miles south of Little Current, in the Sheguiandah formation.

Range. Originally described from Cincinnati, Ohio, in the Eden formation, and widely distributed at this horizon in Ohio, Indiana, Kentucky, Pennsylvania, Maryland, and other states containing Eden faunas. Identified from the Indian Ladder beds of New York.

Although relatively abundant no specimens suitable for illustration are at hand. Figure 3 *e, f, g*, Plate 64, volume 1, Paleontology of New York, represents a specimen of about the same size as *C. granulosa*, from Cincinnati, Ohio, but it may be merely a small specimen of *C. meeki*.

Calymene meeki Foerste
Plate XLV, Figure 11 *a*, *b*

Calymene meeki Foerste, Bull. Sci. Lab. Denison Univ., 16, 1910, p. 84, pl. 3, fig. 18. Ibid, 19, 1919, pl. 18, fig. 3.

Glabella relatively short, with a tendency toward truncation anteriorly. Anterior border of cephalon turned up abruptly and separated from the front of the glabella by a narrow groove. Genal angles with a short, acute, pointed extremity. Ribs of the pygidium with only a very faint trace of an impressed zone along their median line.

This is the species usually identified as *Calymene callicephala* Green, but which cannot be identified with any known species of *Calymene*.

Locality and Horizon. Originally described from Cincinnati, Ohio, in the Maysville formation, and widely distributed at the same horizon in Ohio, Indiana, Kentucky, Tennessee, and probably also in other states.

Calymene callicephala Green

Calymene callicephala Green, Mon. Tril. N.A., 1832, p. 30, cast 2.
Calymene callicephala Clarke, Geol. Minnesota, 3, pt. 2, 1894, p. 699, fig. 2.

The type of this species was a specimen in the Philadelphia Museum, now lost, which was labelled as coming from Hampshire, Virginia, presumably Hampshire county, in West Virginia, since no other town of Hampshire in Virginia is known. The label evidently is an error, since this county does not contain any strata in which *Calymene* could be found.

Type characterized by the protrusion of the border anterior to the glabella, giving it a triangular outline as in *C. senaria,* rather than by the upturned rostral border found in *C. meeki.* Entirely aside from the great distance between the anterior border of the glabella and the anterior margin of the cephalon, a feature not known in any American species of *Calymene,* this protrusion of the rostral border is sufficient to prevent referring *C. meeki*, the characteristic Maysville species, to *C. callicephala.*

Green's identification of the Cincinnati species with his *C. callicephala* is an error.

Calymene retrorsa Foerste

Plate XLIV, Figure 2; Plate XLV, Figure 15

Calymene meeki retrorsa Foerste, Bull. Sci. Lab. Denison Univ., 16, 1910, p. 85, pl. 3, fig. 19. Ibid. 19, 1919, p. 76, pl. 18, fig. 2.

Differs from *Calymene meeki* chiefly in the genal angle being rounded instead of more or less acute.

Calymene retrorsa minuens (Plate XLV, Figure 14). In the Whitewater member of the Richmond formation, both in Ohio and Indiana, a form of *Calymene* occurs which has all the characteristics of *C. retrorsa* but is constantly of smaller size. Originally described from Richmond, Indiana.

Locality and Horizon. Originally described from Dunlapsville, Indiana, and widely distributed in the Waynesville member of the Richmond formation in Ohio, Indiana, and Kentucky.

Calymene sp.

Plate XLV, Figure 10

In Canada the genus *Calymene* is widely distributed at various horizons in upper Ordovician formations, but no attempt has been made to discriminate the different species.

In the Nicolet River section *Calymene* ranges from the Lorraine, *Cryptolithus* zone, through the *Leptœna, Proetus,* and *Pholadomorpha* zones. It occurs in the *Cryptolithus* zone also at Petite Caroline, St. Hugues, and St. Hyacinthe; in the *Proetus* zone also at Vars and Hawthorne; and in the *Pholadomorpha* zone at Vars and Weston.

The specimen figured from the Don brick-yard is similar to *C. meeki* in outline, including the backward curvature of the acutely pointed genal angles. It differs in being more coarsely granulated than in typical *C. meeki*, in that resembling *C. whittakeri* from the Collingwood shale at Fields, Ontario.[1]

Specimens of *Calymene* from the Sheguiandah or Eden shale on Manitoulin island are regarded as belonging to *C. granulosa*, and those in the Wekwemikongsing as *C. meeki*, but both forms require further study.

Calymene occurs in the Waynesville on Snake island, at Oakville, and at Meaford. The relative scarcity of Calymene in the Waynesville of Canada is remarkable and it is practically absent from all horizons of the Richmond on Manitoulin island.

Ceraurinus marginatus Barton
Plate XLVI, Figure 6 *a, b*

Ceraurinus marginatus Barton, Bull. Mus. Comp. Zool., 54, 1913, p. 550, pl. fig. 1.

Glabella subrectangular, with parallel, straight sides. All three pairs of glabellar furrows perpendicular to the dorsal furrows and nearly parallel to each other. Posterior pair of glabellar furrows straight, curving backward only slightly, thus failing to connect directly with the neck furrow. Basal glabellar lobes only faintly separated from the median part of the glabella. All of the glabellar furrows almost directly transverse to the length of the glabella. The posterior three pairs of lobes have approximately the same size. Glabella smooth, and the pitting of the fixed cheek very faint, seen best on that part which extends beyond the palpebral lobes. The ocular ridge extends from a point slightly posterior to the first pair of glabellar furrows to a point half-way between the extensions of the second and third pairs of furrows. Palpebral lobe abruptly defined along its inner margin by a narrow groove curving forward along the lower margin of the suture between the fixed and movable cheeks. The facial suture evidently cuts the anterior margin of the cephalon at a point about 1·5 mm. toward the middle of the cephalon from a line connecting the exterior extremities of the three pairs of lateral lobes of the glabella. The posterior part of the facial suture curves slightly forward from the posterior part of the palpebral lobe, as far as the groove outlining the inner margin of the lateral border of the cephalon, and then curves rather evenly backward, so as to cut the lateral margin at a point anterior to the lateral projection of the furrow outlining the posterior border of the cephalon.

Length of the cephalon here described, along its median line, 14 mm. Greatest width of the fixed cheek, posteriorly, 10·5 mm. The genal spine extends 3·5 mm. beyond the posterior margin of the fixed cheek. Lateral border of the fixed cheek formed by a rounded ridge, less than a millimetre in width, exterior to which the margin is concave for a width slightly over one millimetre. Both the rounded ridge and the concave marginal part continue posteriorly as far as the extremity of the genal spine.

[1] Ohio Jour. Sci., 1919, pl. 19, figs. 9 A, B.

A single pygidium, probably of the same species, was found associated with the preceding specimen in the same layer. It possesses three axial segments, diminishing rapidly in width, posteriorly. Lateral lobes formed by three pleural segments, on each side of the pygidium, all segments extending beyond the margin of the pygidium, and bordering it with blunt spines. Of these, the anterior spine is ridged lengthwise, similar to the free pleural segments of the thorax.

This species evidently is closely related to *Ceraurinus icarus* (Billings) (Plate XLIV, figure 3 *a*, *b*) from the English Head, Vaurial, and Gamachian members of the Richmond formation on Anticosti island. It is characterized by having the posterior pair of glabellar lobes nearly isolated from the remainder of the cephalon. A form similar to or identical with the latter is *C. meekanus* from the Whitewater member of the Richmond in Ohio and Indiana. Forms similar to *C. icarus* occur also in the Richmond of Iowa and at Stony Mountain, in Manitoba.

Locality and Horizon. No. 8555 *a*, right half of cranidium; No. 8555 *b*, pygidium; from the Kagawong formation 4 miles southwest of Little Current.

Range. Originally described from Manitoulin island, in the Richmond.

Technophorus quincuncialis Foerste
Plate XXX, Figure 13 *a*, *b*

Technophorus punctostriatus quincuncialis Foerste, Bull. Sci. Lab. Denison Univ., 17, 1914, p. 316, pl. 2, figs. 13 A, B.

Specimens 9 or 10 mm. long, so closely related to *Technophorus punctostriatus* Ulrich that it can be described best by noting the differences.

If a line be drawn vertically downward from the beak toward the basal margin, then the basal margin of *T. quincuncialis*, posterior to this line, will be found to be more convergent with the dorsal margin, forming an angle of about 10 degrees with an horizontal line. The two sigmoidal ridges crossing the posterior half of the valves, from the beak toward the lower part of the posterior margin, are more oblique, the anterior one forming an angle of about 40 to 43 degrees with an horizontal line; convex part of curve near beak relatively much longer, and concave part, toward postero-ventral angle, correspondingly shorter. Only one specimen shows the character of the ornamentation between the two sigmoidal ridges. It consists of striæ, about 3·5 in number in a width of 0·5 mm.; much wider than the concentric striæ on the main body of the valves, but occurring at about the same intervals as the concentric striæ where the latter are most distant from each other on the anterior part of the body; in direction, they form angles of about 55 degrees with an horizontal line, or about 15 degrees with the general trend of the anterior sigmoidal ridge, in this respect resembling *T. divaricatus* rather than *T. punctostriatus*.

The posterior or cardinal wing, behind the second sigmoidal ridge, bears no ornamentation of any kind on any of the specimens at hand. Interior ridge or so-called clavicle extending from the anterior part of the beak toward the basal margin, 2 mm. in length. Its position frequently can be detected on the exterior of the valve. Along the upper part of the body, between the clavicle and the anterior sigmoidal ridge, concentric striæ ornamenting the exterior approximately horizontal, but, ventrally from this part of the body, they become parallel to the lower margin. Anterior to the anterior sigmoidal ridge, for distances varying from 1·5 mm. toward the dorsal margin, to 2·5 mm. near the middle, and from 5 to 6 mm. near the basal margin; the spaces between the concentric striæ are crossed by short, transverse striæ more closely crowded toward the sigmoidal ridge, but becoming more distant anteriorly; over the central parts of the main body the ornamentation takes more of the nature of circular or rounded hexagonal pits having a quincuncial arrangement. The concentric striæ only are distinctly indicated directly below and in front of this quincuncially ornamented area, however, within 0·7 mm. of the ventral and anterior margins.

T. punctostriatus Ulrich was described originally from the Fairmount division of the Maysville formation at Covington, Kentucky.

Locality and Horizon. Chambly, Richelieu river, and mouth of Huron river, in the *Proetus* zone of the Lorraine. Originally described from the former locality.

No. 8415, from Chambly, associated with *Pholidops subtruncatus* Hall and a free cheek of *Proetus chambliensis.*

No. 8413, from same locality, associated with *Catazyga headi* (Billings) and *Plectambonites rugosus* (Meek).

No. 2076, from same locality, associated with *Pholidops subtruncatus* Hall and *Byssonychia radiata* (Hall).

Leperditia cæcigena Miller
Plate XLV, Figure 6 *a, b*

Leperditia cæcigena Ulrich, Jour. Cincinnati Soc. Nat. Hist., 13, 1891, p. 176, pl. 11, figs. 6 *a-d.*

Valves 4 to 5 mm. long, thick-shelled, smooth and glossy; obliquely ovate in form, larger posteriorly, and rather evenly convex. Without any trace of either an eye tubercle or a muscle spot. The right valve overlaps the left all around the free margins.

Locality and Horizon. Originally described from Versailles and Osgood, Indiana, and widely distributed in the southeastern part of that state, in the Saluda member of the Richmond formation.

Similar specimens appear to occur in the Kagawong member at Kagawong, Little Current, Manitowaning, and Clay cliffs. Also in the fossiliferous zones of the Queenston shale, northwest of Meaford, south of Georgian bay.

No. 8422, from 4 miles northwest of Meaford, along the north and south road bordering lot 24, in concession VIII, in the Queenston shale.

Leperditia manitoulinensis sp. nov.
Plate XLVI, Figure 1 *a-d*

Length 7 mm.; height 4 mm.; approximate convexity of a single valve about 1·5 mm. Elliptical oblong in outline, with straight hinge-margin rounding into the oblique upper part of the posterior margin. Anterior margin more rapidly rounded than the posterior. Greatest angularity of outline at the junction of the anterior outline with the hinge-line. Greatest convexity of curvature a little anterior to and a little below the centre of the valve, sloping thence more rapidly toward the lower, rather than toward the upper, margin of the valve. Antero-posteriorly rate of curvature increased only moderately at the point of greatest vertical transverse curvature of the valve.

These specimens differ from typical *L. cæcigena* in the greater transverse curvature of the valves, especially toward their centre, where there is a tendency toward angularity. Overlapping part of the right valve much broader, having a width of over 1 mm. in a specimen 6·5 mm. long.

Locality and Horizon. From Clay cliffs, in the Meaford (No. 8520).

Leperditella (?) *glabra* Ulrich
Plate XLV, Figure 5

Primitia glabra Ulrich, Jour. Cincinnati Soc. Nat. Hist., 13, 1890, p. 134, pl. 10, figs. 9 *a-c*.

Valves 1·9 mm. long; moderately convex; greatest convexity nea middle of posterior half. Free margin with narrow flange. A broad^r shallow, poorly-defined depression extends from the middle of the hinge-' line to the centre of the valve.

Locality and Horizon. Northwest of Meaford. In the Queenston formation.

Range. In the Whitewater member of the Richmond formation. Originally described from Oxford and Blanchester, Ohio; known also from Richmond, Indiana.

Ceratopsis oculifera (Hall)
Plate XLV, Figure 1 *a, b*

Beyrichia oculifera Hall and Whitfield, Geol Surv., Ohio, Pal. 2, 1875, p. 103, pl. 4, figs. 9, 10.

Valves 2 mm. long. Near posterior extremity of hinge-line an ocular or disk-shaped elevation rises abruptly on a short pedestal above the general surface. Two broad, lunate grooves, directed downward and backward, define an oblique, median ridge and leave a broad, elevated area along the margin of the body of the valve. Free margins distinctly flanged.

Locality and Horizon. St. Hilaire, in the *Pholadomorpha* zone of the Lorraine.

Range. Originally described from Cincinnati, Ohio, in the Corryville member of the Maysville formation.

Ctenobolbina ciliata (Emmons)
Plate XLV, Figure 2

Beyrichia tumidifrons Hall and Whitfield, Geol. Surv., Ohio, 2, 1875, p. 102, pl. 4, fig. 8.

Valves 1·8 mm. long. Free margins with a narrow, flattened border, on the under side of which is a series of small denticulations. Posterior two-fifths of valve decidedly bulbous, defined from anterior three-fifths by a deep, narrow groove extending in a curve from near the middle of the hinge-line downward and backward. Another sub-parallel but fainter groove located about one-fifth of the length of the valve farther forward. Surface generally granulose.

Locality and Horizon. Nicolet River section and St. Hilaire, in the *Pholadomorpha* zone of the Lorraine. Apparently also at Vars, in the *Proetus* zone.

Range. Originally described from Cincinnati, Ohio. In the Eden formation. Also identified from the Snake Hill member of the Trenton in New York. Somewhat similar forms occur in the Richmond formation. Among these are *C. hammeli* Miller and Faber, from Versailles, Indiana, and *C. emaciata* (Ulrich) from the Maquoketa member of the Richmond formation. It is evident that the Canadian specimens should be subjected to a closer discrimination, since the *Pholadomorpha* zone contains a number of forms suggesting a Richmond age.

Drepanella richardsoni canadensis Ulrich
Plate XLVI, Figure 5 *a, b, c*

Drepanella richardsoni canadensis Ulrich, Jour. Cincinnati Soc. Nat. Hist., 13, 1890, p. 118.

Valves averaging 2·5 mm. in length. Running nearly parallel with the posterior and ventral edges is a sharply elevated sickle-shaped ridge, with two additional vertical ridges reaching the dorsal margin along the more central parts of the valve. Surface of the valves strongly and more or less regularly pitted, or reticulated.

Length of largest specimen 2·8 mm., height 1·7 mm. Dorsal margin straight, anterior margin more convex than any other part of the outline, posterior margin inclined moderately forward. Posterior and lower margin of the valve occupied by a narrow, elevated border merging anteriorly with the general flattening of the anterior face of the valve. A short distance within this narrow raised border, and parallel to the latter, is the sickle-shaped ridge, barely a fourth of a millimetre in width along its posterior part, diverging from the ventral part of the valve anteriorly, and terminating abruptly within half a millimetre from its anterior margin. Six-tenths of a millimetre in front of the upper posterior end of the sickle-shaped ridge, the posterior one of the two short vertical ridges extends downward from the dorsal margin toward the lowest part of the sickle-shaped ridge, and an equal distance still farther to the front the anterior one of the two short vertical ridges, which is broader and shorter, extends from the dorsal margin downward only for a short distance and then merges into the general convexity of the posterior part of the large anterior lobe of the valve. The posterior part of this anterior lobe extends diagonally downward and backward, joining the sickle-shaped ridge in such a manner as to form a U with an oblique base, with its lower and posterior part. Along the middle of this U extends the posterior one of the two short vertical ridges described above. General curvature of the anterior lobe strongly flattened along its upper anterior area. Surface of the valve strongly pitted or reticulated in the U-shaped depression, on the anterior lobe, especially along its lower half, and along the ventral part of the valve.

Locality and Horizon. North and south road, 4 miles northwest of Meaford, along lot 24, concession VIII. In the Queenston.

Range. Originally described from the basal part of the Queenston at Oakville, Ontario. The species *Drepanella richardsoni* Miller was described originally from the top of the Whitewater member of the Richmond formation near Wilmington, Ohio.

Eurychilina (?) *striatomarginata* (Miller)

Plate XLV, Figure 8; Plate XLVI, Figure 4

Eurychilina striatomarginata Ulrich, Jour. Cincinnati Soc. Nat. Hist., 13, 1890, p. 130, pl. 9, fig. 14.

Valves about 1·7 mm. long. Body of valve convex, with a groove extending from the middle of the hinge-line to or beyond the centre of the body. Ventral margin with wide, frill-like border, radiately striated.

Length of convex part of valve 1·9 mm.; height of convex part, 0·9 mm.; width of flattened border along ventral part of valve, 0·45 mm., giving a total height of about 1·4 mm. without the border, and of about 2·5 mm. including this border. Outline of raised part or body of valve almost elliptical in a transverse direction. The convexity of this part very moderate, excepting along the anterior margin where the surface descends rapidly to the groove separating the relatively broad, flattened border from the convex body of the valve. The border varies in different specimens from gently convex to moderately convex. It is minutely striated in a radiate direction. Near dorsal margin of body of valve is a low, narrow ridge, more or less obliquely curved at the posterior extremity. A narrow but very distinctly defined groove traverses the body slightly anterior to the middle. It begins a short distance below the dorsal margin and terminates abruptly at a third of the height of the body from its base. Toward the dorsal margin this groove is continued as a very shallow, rapidly widening depression, usually far less conspicuous than the sharply-defined groove.

Locality and Horizon. North and south road, along lot 24, concession VIII, 4 miles northwest of Meaford (No. 8525). In the Queenston.

Range. Originally described from Osgood, Indiana, in the Saluda division of the Whitewater member of the Richmond formation, and widely distributed at that horizon in southeastern Indiana.

Jonesella crepidiformis (Ulrich)
Plate XLV, Figure 7

Jonesella crepidiformis Ulrich, Jour. Cincinnati Soc. Nat. Hist., 13, 1890, p. 122, pl. 7, figs. 8 *a-c*.

Valve about 1 mm. long, with a ridge shaped like a horse-shoe, occupying slightly more than the posterior half of the valve.

Locality and Horizon. Gorrel point, northeast of Gore Bay. In the Sheguiandah formation.

Range. Originally described from Covington, Kentucky, and known hitherto only from the area surrounding Cincinnati, Ohio, where it occurs in the lower or Economy member of the Eden formation.

Laccoprimitia centralis Ulrich
Plate XLV, Figure 3

Primitia centralis Ulrich, Jour. Cincinnati Soc. Nat. Hist., 13, 1890, p. 130, pl. 10, figs. 1, 2 *a-c*.

Valves 0·6 to 0·75 mm. long. Both the anterior and the posterior margins meet the hinge-line without forming distinct angles. Free borders with a narrow flange. Sub-central, circular depression, not connected with the hinge-line by a distinct groove.

Locality and Horizon. Gorrel point northeast of Gore Bay, and Tamarack point north of Honora, Manitoulin island. In the Sheguiandah fomation.

Range. Originally described from Cincinnati, Ohio, where it ranges from the Cynthiana formation through the Eden and Maysville formations.

Primitia lativia Ulrich
Plate XLV, Figure 4; Plate XLVI, Figure 3

Primitia lativia Ulrich, Geol. Surv., Can., Cont. Micro-Pal., pt. 2, 1889, p. 50, pl. 9, figs. 8, 8 *a*.

Valves about 1·35 mm. long, with a wide, strongly impressed groove extending from near the middle of the hinge-line to the centre of the valve; posterior border of groove more abrupt and more elevated than the anterior. No distinct border present, but the margin frequently flares a little.

Length 1·4 mm.; height 0·9 mm. Dorsal margin straight, ventral margin convex, anterior margin slightly more convex than the posterior. Surface convex, with a tendency toward a narrow border around the margin. Sulcus varying from narrow and sharply impressed to broad and comparatively shallow, located slightly anterior to the middle of the valve, and curved in form, with the concave curvature toward the front of the valve. Sulcus extending nearly two-thirds of the height across the valve, its position marked on the interior of the valve by an acute ridge. Valves not overlapping. A narrow groove appears to extend around the anterior two-thirds of the margin of one valve, for the reception of the acute margin of the opposite valve.

Locality and Horizon. Gore Bay, Kagawong, and Manitowaning. In the Kagawong formation, 4 miles northwest of Meaford, along the north and south road, lot 4, concession VIII, in the Queenston (No. 8523).

Range. Originally described from Stony Mountain, in the Richmond formation. Widely distributed in southeastern Indiana in the Saluda division of the Whitewater. Also known from Stony Mountain, Wyoming, and in the Vaurial member of the Richmond on Anticosti island.

Bythocypris cylindrica (Hall)
Plate XLVI, Figure 2

Bythocypris cylindrica Ulrich, Geol. Minnesota, 3, pt. 2, 1894, p. 687, pl. 44, figs. 29-35.

Valves elongate ovate elliptical, more narrowly rounded anteriorly; dorsal margin more or less convex, rounding almost imperceptibly into the oblique upper half of the posterior margin; lower margin straight or faintly concave. Surface smooth. Length 1·25 mm.

Locality and Horizon. In Quebec and in the area east of Ottawa this species has been found in the *Proetus* zone of the Lorraine at Chambly Canton and at Vars, and in the *Pholadomorpha* zone in the Nicolet River section and also near Vars. Northwest of Meaford, Ontario, it occurs in the Queenston red clay shales. On Manitoulin island it occurs at Gorrel point, northeast of Gore Bay, in the Sheguiandah, and at Kagawong, Manitowaning, and Clay cliffs it is found in the Kagawong.

Range. Originally described from Cincinnati, Ohio, and widely distributed through Indiana, Kentucky, Tennessee, Minnesota, and New York, as far northward as Manitoba, Ontario, and Quebec.

It ranges from the Trenton to the Richmond formation.

Lepidocoleus jamesi Hall and Whitfield
Plate XLV, Figure 9 *a, b, c*

Plumulites jamesi Hall and Whitfield, Geol. Surv., Ohio, Pal. 2, 1875, p. 106, pl. 4, figs. 1-3.

Lepidocoleus jamesi Faber, Jour. Cincinnati Soc. Nat. Hist., 9, 1886, p. 18, pl. 1, figs. A-F.

Detached plates 1·5 mm. long, subtriangular in outline. Basal margin sigmoidal, with the convex part nearer the longer lateral side of the plate. Surface faintly depressed along the middle, and crossed by striæ parallel to the sigmoidal base.

Locality and Horizon. Tamarack point, north of Honora, Manitoulin island.

Range. Originally described from Cincinnati, Ohio. From Cincinnatian formations. Also known apparently from the Trenton of New York.

PLATE I[1]

FIGURE 1. *Streptelasma rusticum* (Billings), a, b, c. Three specimens showing variation in rate of enlargement and of curvature in different individuals. No. 8529, Clay cliffs, Richmond. (Page 65.)

FIGURE 2. *Streptelasma rusticum* (Billings). Specimens indicating methods of attachment of different individuals during early stages of growth. *a*, no evidence of any attachment area is present; early attachment may have been strictly terminal. *b*, attachment area small, concave, sublateral, on cardinal side of coral; cardinal line forms right margin of figure; attachment area forms concave outline at very base of specimen. *c*, attachment area larger, facing observer at base of specimen; area slightly concave, on cardinal side of specimen; cardinal septum near median line of figure. No. 8573, Clay cliffs, Richmond. (Page 65.)

FIGURE 3. *Protarea richmondensis papillata* Foerste. *a*, stroma encrusting brachial valve of *Hebertella insculpta*, showing numerous papillæ arranged so as to suggest calyces. *b*, thin stroma encrusting brachial valve of *Strophomena huronensis* Foerste, with papillæ of the *Protarea* showing a tendency toward alignment along the stronger radiating striæ of the *Strophomena*. The grouping of papillæ so as to suggest calyces is vague where stroma is very thin, but much more distinct toward lower right hand part of figure where it is thicker. Both figures magnified X 2. No. 8533, Clay cliffs, Richmond. (Page 74.)

FIGURE 4. *Protarea richmondensis* Foerste. Papillæ arranged so as to suggest distinct calyces with twelve short septa. Appearance of septa due to elongation of papillæ in a radial direction, or to arrangement of several small papillæ in this direction. In central part of calyces arrangement of papillæ irregular. Magnification: X 2. No. 8535, bluff southwest of Gore Bay village; Richmond. (Page 73.)

[1] When not otherwise specified figures are approximately natural size; a slight reduction of the plates by the engraver makes the figures a little less than natural size.

Plate No. I

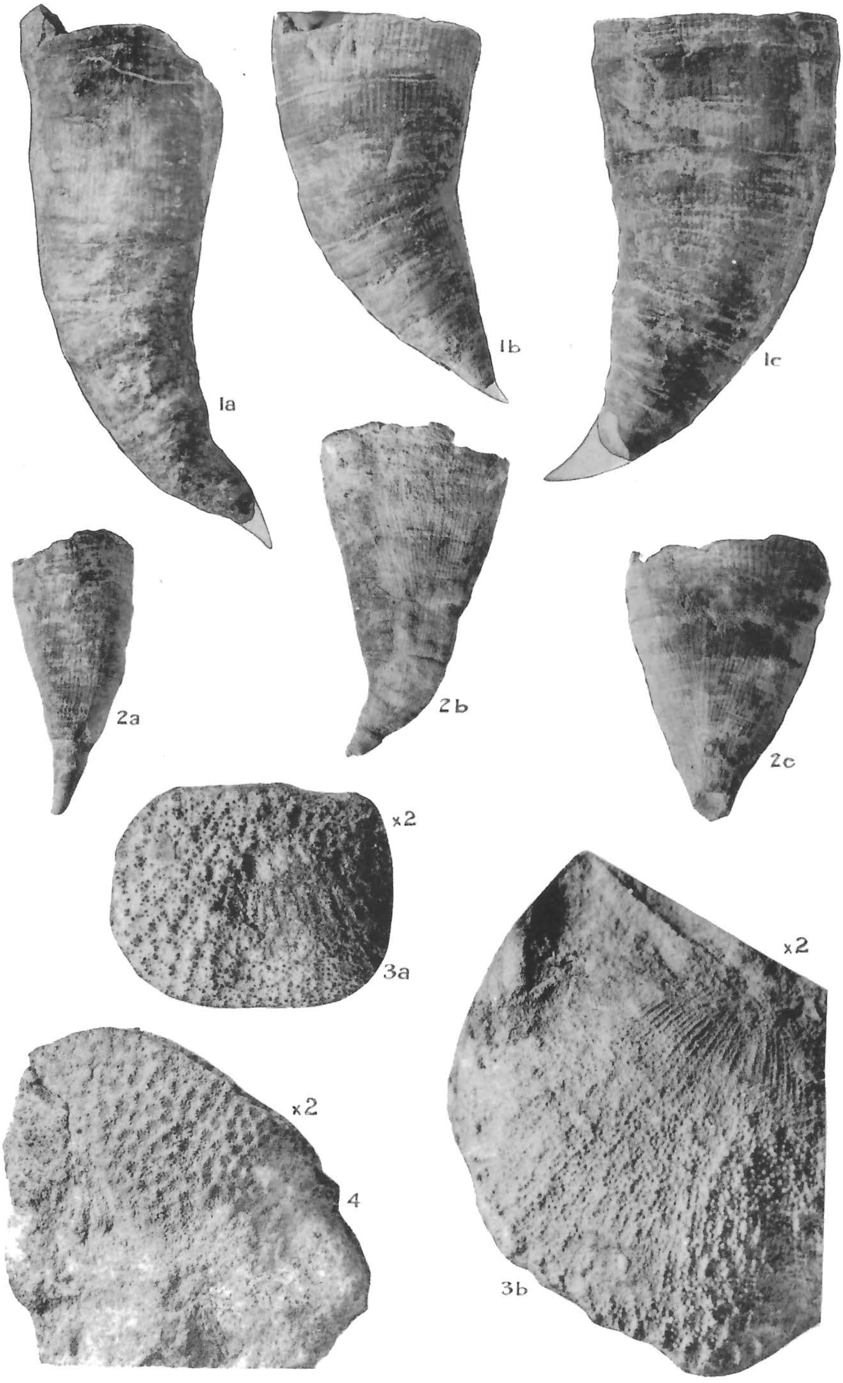


Plate II

Figure 1. *Beatricea undulata* Billings. Lateral view. Bardstown, Kentucky; lower part of Liberty member, Richmond. Bull. Denison Univ., 14, 1909, pl. 8, fig. 3. (Page 76).

Figure 2. *Stromatocerium huronense* (Billings). Natural vertical weathered section showing transverse laminæ and vertical pillars. Clay cliffs, Richmond. (Page 74).

Figure 3. *Girvanella richmondensis* (Miller). Polished section across numerous specimens embedded in the same rock, showing concentric lamination. Richmond, Indiana; upper part of Whitewater member of the Richmond. Jour. Cincinnati Soc. Nat. Hist., 5, 1882, pl. 2, fig. 1. (Page 65).

Figure 4. *Streptelasma dispandum* Foerste. Lateral view, with nearer edge of the calyx broken off and part of circumference restored. Moores Hill, Indiana; upper or Blanchester division of Waynesville member, Richmond. Bull. Denison Univ., 14, 1909, pl. 9, fig. 4. (Page 66).

Figure 5. *Streptelasma divaricans* (Nicholson). *a*, lateral view. *b*, a group viewed from above. *c*, *d*, two views of same calyx seen from above, the second enlarged. Osgood, Indiana; Whitewater member, Richmond. Bull. Denison Univ., 14, 1909, pl. 10, figs. 4 A, B, C, E. (Page 67).

Figure 6. *Streptelasma rusticum* (Billings). *a*, lateral view. *b*, lateral view with part of wall of calyx broken away, showing interior. *c*, base of calyx, with the lateral walls of calyx broken off. Dayton, Ohio, Whitewater member, Richmond. Bull. Denison Univ., 14, 1909, pl. 11, figs. 1 A, B, C. (Page 65).

Plate No. II

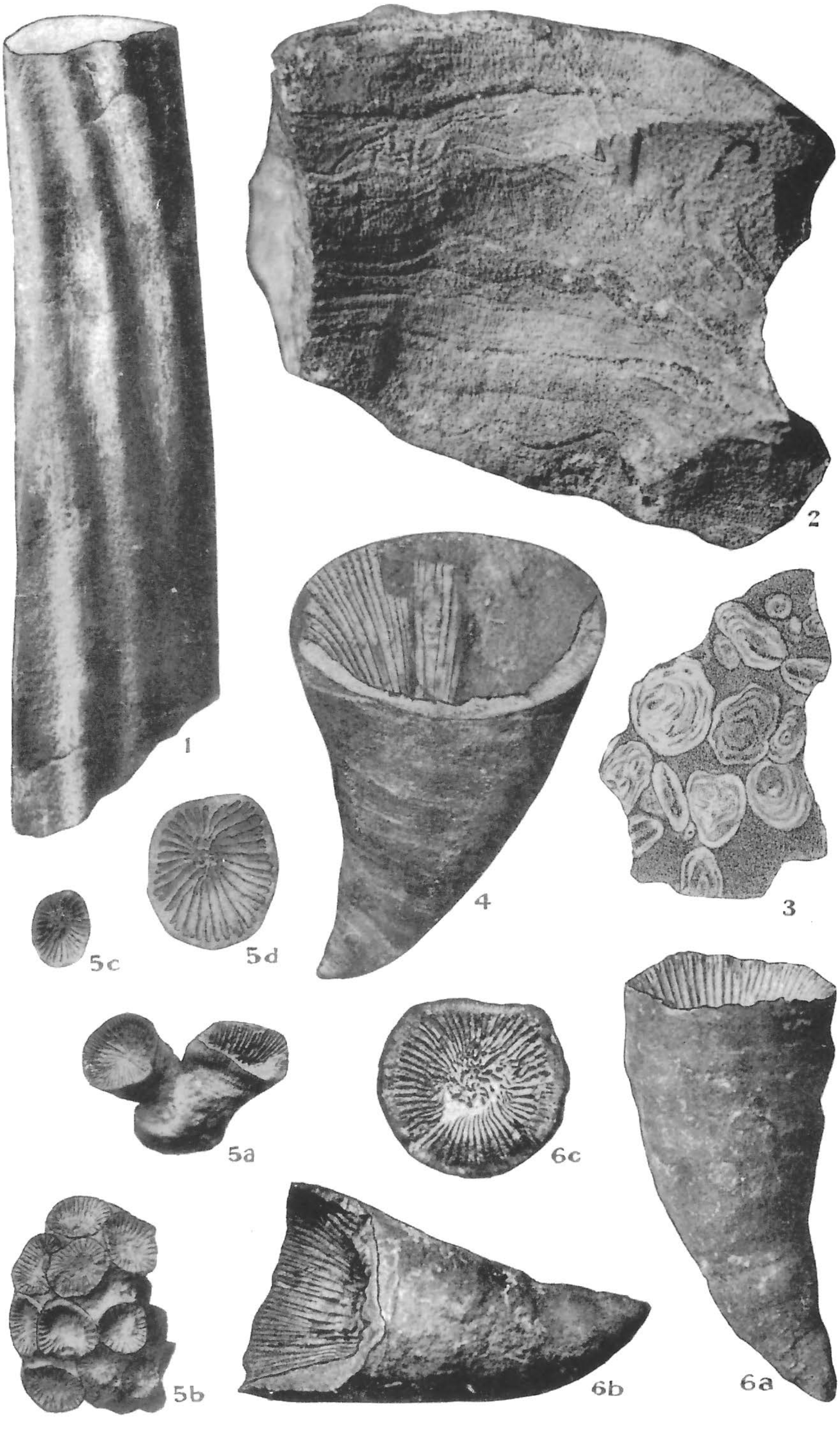
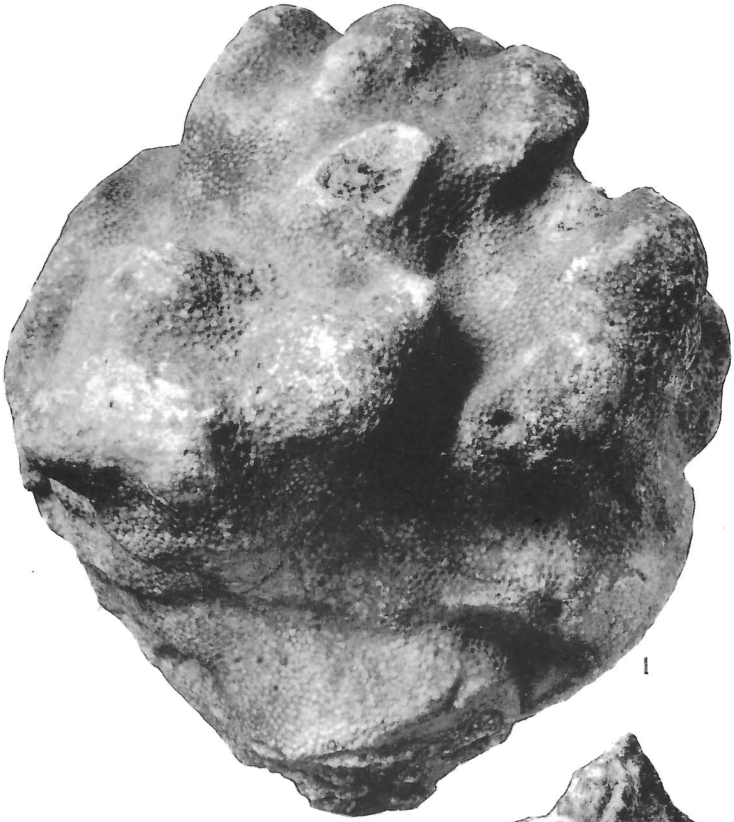


Plate III

Figure 1. *Lyopora goldfussi* (Billings). Corallum in its erect position, showing the lobate character of upper surface; about twelve lobes, all of moderate height; vertical axis 11·5 c.m.; calyces rounded. No. 1764, Snake island; Richmond. (Page 69).

Figure 2. *Stromatocerium huronense* (Billings). Basal side of coenosteum, showing several centres of growth; one in centre of figure, another diagonally beneath it toward the left; a third near the angle at mid-height along the right margin. This basal side of the coenosteum is covered by a very thin, epithecal layer, concentrically wrinkled around each centre of growth. A slight amount of weathering is sufficient to expose radial lines formed by the discontinuous pillars which in the upper part of the coenosteum are more nearly vertical and pass through successive laminæ building up the more or less massive individuals. No. 8436, Clay cliffs; Richmond. (Page 74).

Plate No. III



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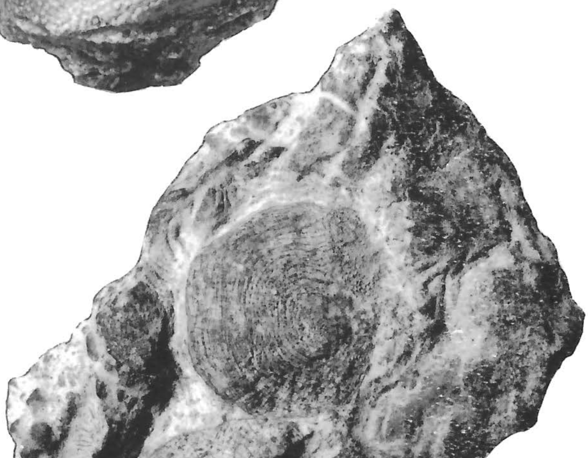

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PLATE IV

FIGURE 1. *Tetradium huronense* Foord. *a,* corallum viewed from above. *b,* cross-section of several corallites enlarged. Mouth of Bull creek, Indiana; Richmond. Bull. Denison Univ., 14, 1909, pl. 10, figs. 1 A, B. (Page 71).

FIGURE 2. *Calapoecia huronensis* Billings. Corallum viewed from above. Bardstown, Kentucky; Liberty member, Richmond. Bull. Denison Univ., 14, 1909, pl. 11, fig. 4. (Page 69).

FIGURE 3. *Columnaria calicina* (Nicholson). *b,* corallum viewed from above, showing several discrete corallites with circular outlines. *a,* several discrete corallites with cylindrical outlines. Streetsville, Ontario; Richmond. (Page 68).

FIGURE 4. *Columnaria alveolata* Goldfuss. Corallum viewed from above. Bardstown, Kentucky; base of Liberty member, Richmond. Bull. Denison Univ., 14, 1909, pl. 11, fig. 3. (Page 67).

FIGURE 5. *Arthraria rogersensis* Foerste n.sp. Cynthiana formation, north of Rogers Gap, Kentucky, in the railway cut 59·1 miles from Ludlow. (Page 79).

Plate No. IV

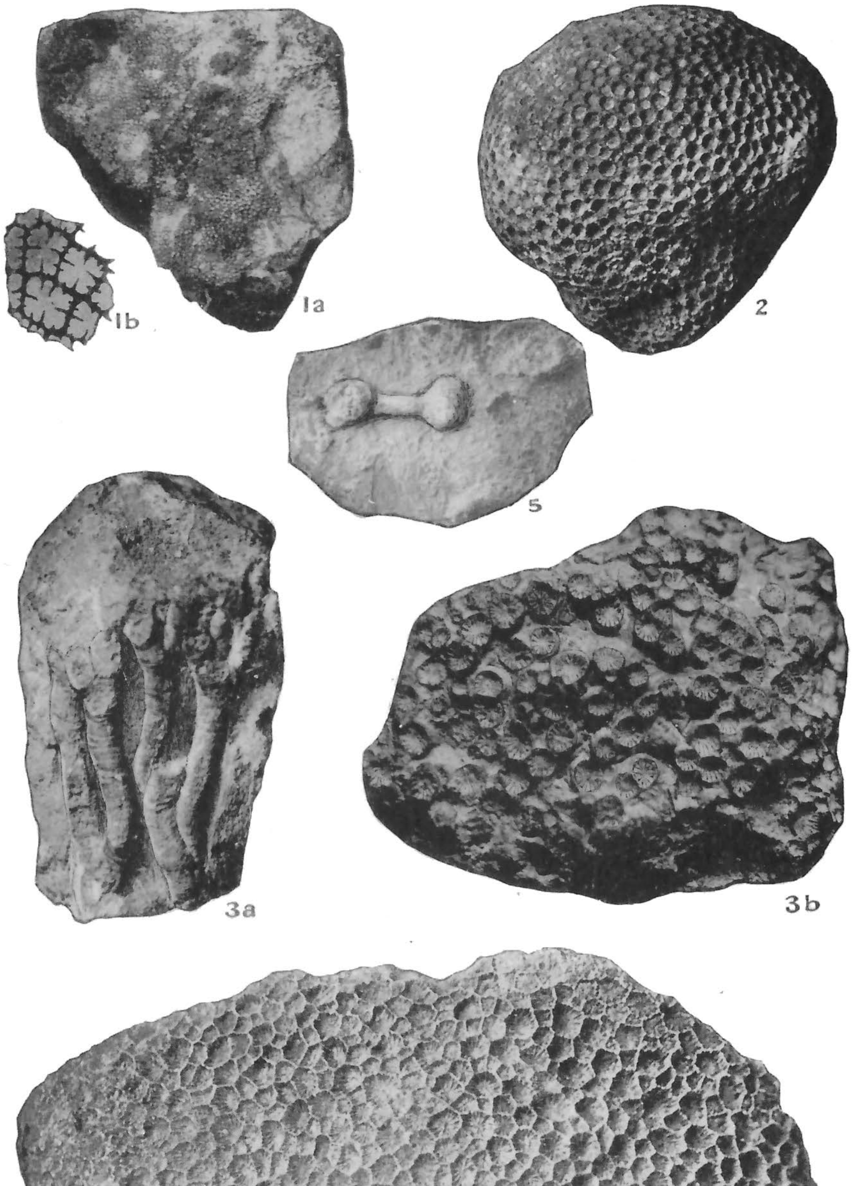


Plate V

Figure 1. *Columnaria alveolata rigida* (Billings). Corallum with relatively large corallites, septa usually extending only a short distance from walls, some reaching centre. *See* upper right hand corner of specimen here figured. Magnification: X 0·9. No. 8438, Snake island; Richmond. (Page 67).

Figure 2. *Columnaria alveolata blainvilli* (Billings). Corallum with relatively small corallites, septa usually reaching centre of the corallites or projecting strongly inward. Nine-tenths of natural diameter. No. 8437, Snake island; Richmond. (Page 67).

Figure 3. *Arthraria biclavata westonensis* Foerste. Specimen consisting of a narrow groove, deepening toward mid-length, and terminating at each end in a more or less circular depression. Humber river, south of the bridge; *Pholadomorpha* zone, Lorraine. (Page 78).

Figure 4. *Strophomena hecuba* Billings. Brachial valve, showing the fine, even, radiating striæ. No. 2016 *a*, Anticosti island; Vaurial division, Richmond. (Page 121).

Figure 5. *Hebertella occidentalis* (Hall). *a*, pedicle valve, with median sinus; *b*, brachial valve, with median fold, but without a median umbonal depression. Nicolet River section. Associated with *Strophomena hecuba;* Waynesville member, Richmond (No. 8439). (Page 110).

Figure 6. *Rafinesquina squamula* (James). Pedicle valve. Magnification: X $1\frac{1}{2}$. From Cincinnati, Ohio; Eden shale. Same specimen as in Bassler, Maryland Geol. Surv., Cambrian and Ordovician, 1919, p. 264, pl. 54, fig. 3. (Page 116).

Figure 7. *Glyptorthis insculpta manitoulinensis* Foerste. Brachial valve, with tip of pedicle valve extending above it. From Clay cliffs, Meaford member, Richmond. (Page 111).

Plate No. V

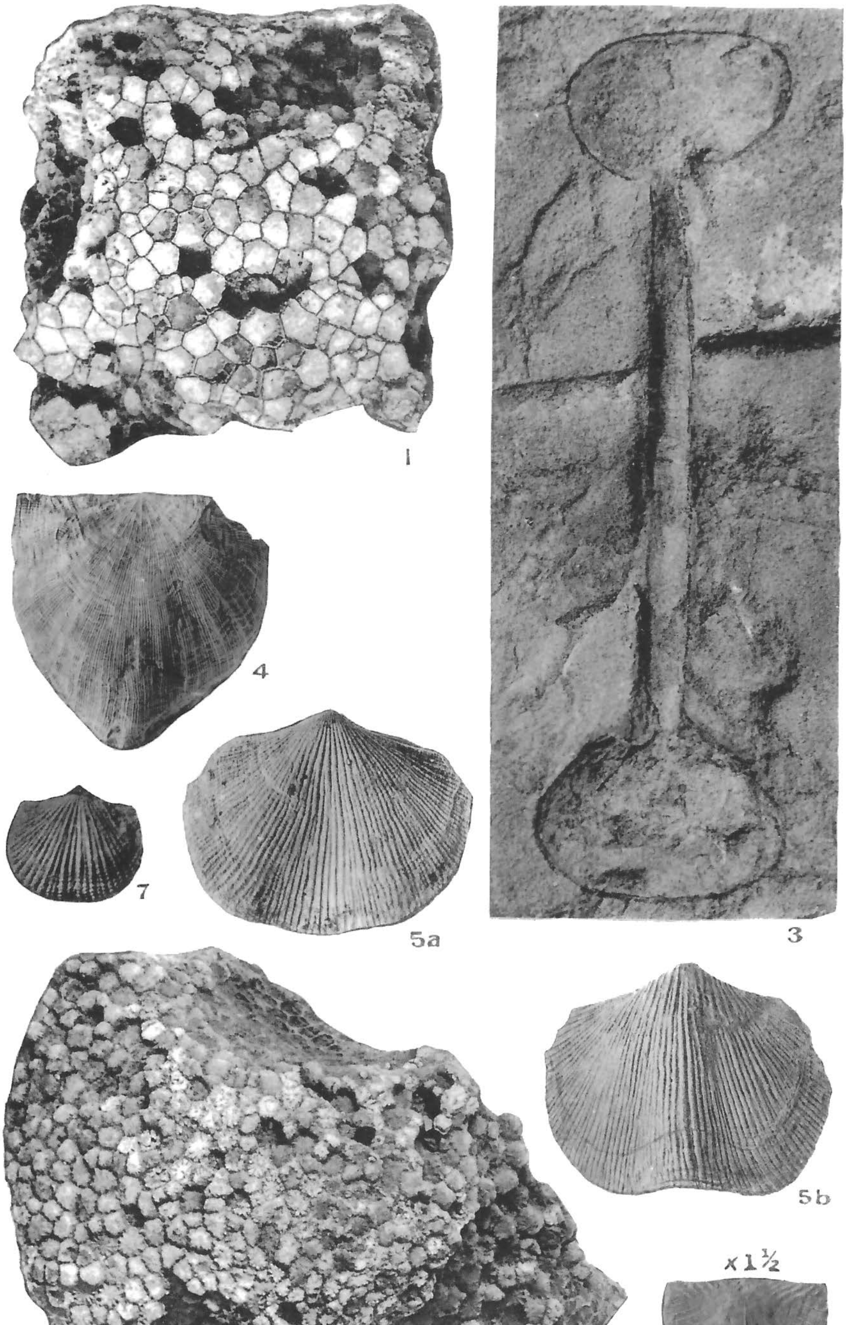


Plate VI

Figure 1. *Compsocrinus harrisi* (Miller). *a*, strongly weathered calyx, showing at its base area of attachment to the quadrangular column. Only the strongly convex, narrow ridges forming the median part of the various brachials well preserved, but enough of the remainder of surface of plates retained to indicate the stellate character of the ornamentation in general. Ornamentation is shown also by crinoid plate lettered A which belongs to the anal interradial series. *b*, another individual, on the same slab as the former, exposing the pinnulate arms. Only a few traces remain of the calyx. At the letter B, in this figure, are elongated elements, probably representing the median ridges of the terminal brachials included in the dorsal cup. *c*, upper end of fragment of column formerly attached to base of specimen 1*a*. Magnification: figure *a*, X 3; figure *b*, X 1½; figure c, X 7. No. 8576, Clay cliffs. Richmond. (Page 103.)

Figure 2. *Lichenocrinus obliquus* sp. nov. Two specimens attached to same crinoid column. Lower specimen retains basal part of column, consisting of five vertical rows of more or less alternating segments. Magnification: X 4. No. 8579, half a mile south of Clay cliffs. Sheguiandah. (Page 102.)

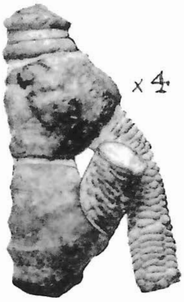
Figure 3. *Cyclocystoides huronensis* Billings. Type specimen showing submarginal ring and upper face of that part of lower disk surrounded by the ring. Except at its centre, this upper face marked radially. Exterior part of plates of submarginal ring marked by oval depressions filled by oval elevations, beyond which extend spout-like appendages. Marginal zone of small imbricating plates not preserved sufficiently well to be recognized in the figure. Magnification: X 2½. No. 1998, Rabbit island. Richmond. (Page 80.)

Figure 4. *Cast of burrow of some unknown animal. a*, viewed from narrower side. *b*, viewed from broader side. Both views show vertical rows of projections which are supposed to locate impressions made by appendages of the burrowing animal. Magnification: X 1½. No. 8581, Clay cliffs. Richmond. (Page 78.)

Plate No. VI

×3 1a

×1½ 1b



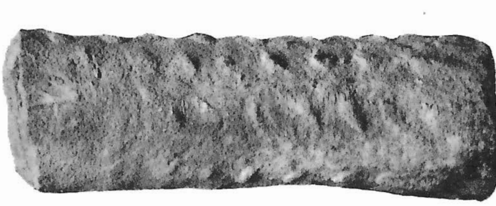
×4

2

3

1c

4a



4b

Plate VII

Figure 1. *Drymocrinus manitoulinensis* sp. nov. *a, b, c, d,* typical specimens, showing geniculate character of the arms, especially near their bases. *e,* another specimen in which the geniculate character of the arms is less conspicuous. In *b* and *c* pinnules are present attached to the top of each geniculate prominence, alternately on the right and left of the arms. In *b, e,* and *f,* there are indications of the anal series at the points marked A. In *f* part of the ventral sack is exposed. Magnification: X 1½. No. 8578, east of Tamarack point; Sheguiandah. (Page 101.)

Figure 2. *Drymocrinus* sp. A calyx, with the top of the column and the lower parts of some of the arms. Anal series exposed at the point A. Lower part of right posterior arms distinctly geniculate as in *D. manitoulinensis*. Other arms poorly exposed. Magnification: X 1½. From the river bed below the dam at St. Hyacinthe; *Cryptolithus* zone of the Lorraine. Collected by R. Harvie. (Page 102.)

Plate No. VII

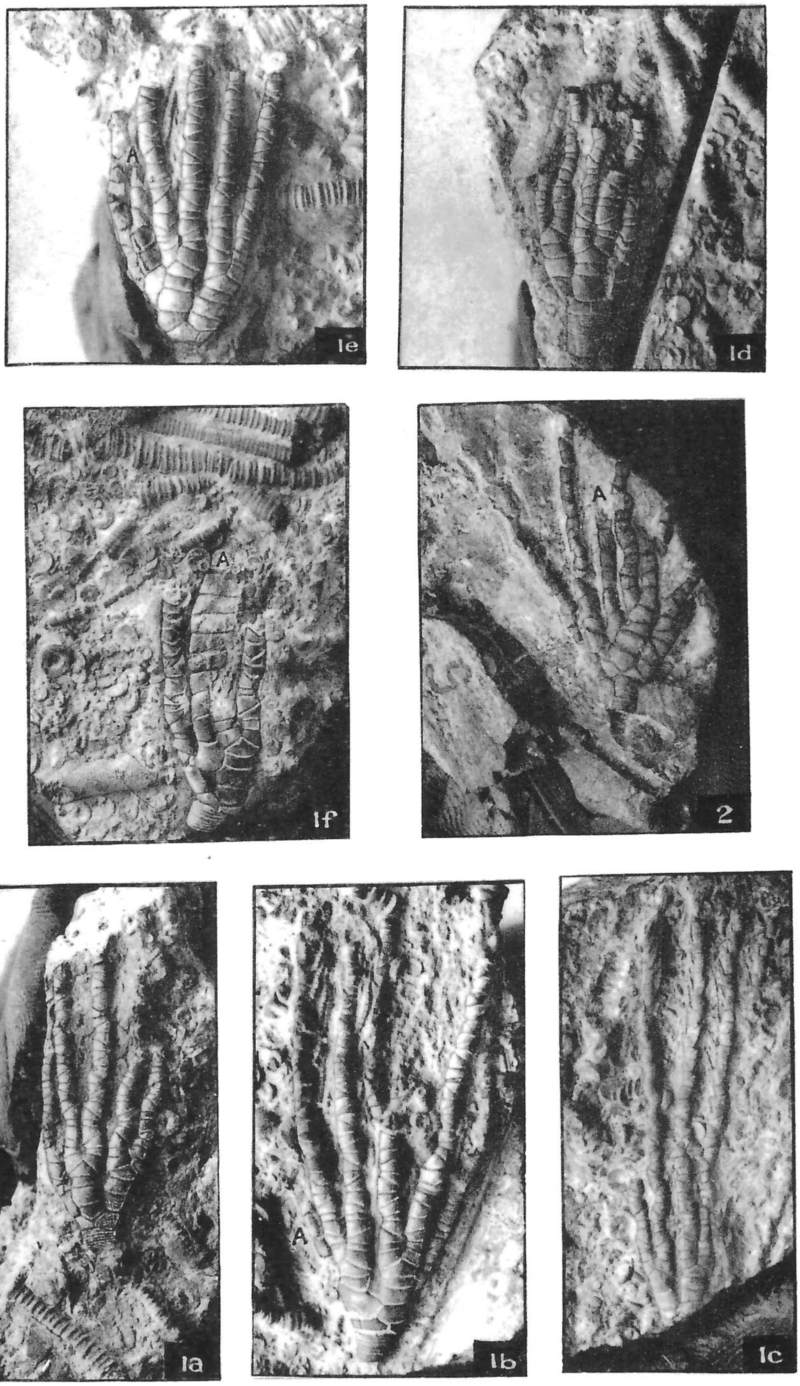


Plate VIII

Figure 1. *Tæniaster meafordensis* Foerste. *a*, *b*, two specimens showing oral side; *c*, specimen showing aboral side, with only the disk and two lower arms well exposed. (Page 104.)

Figure 2. *Tæniaster meafordensis* Foerste. *a*, oral side, poorly preserved; *b*, *c*, aboral side, with surface of one of the arms well exposed at F. (Page 104.)

Figure 3. *Tæniaster meafordensis* Foerste. A specimen with the arms bent back, a common position in the slab, in which hundreds of individuals were crowded closely together. (Page 104.)

Figure 4. *Tæniaster meafordensis* Foerste. Same fragment as in figure 1, magnified X 3, and inverted in position as compared with the latter. (Page 104.)

All of these specimens were obtained from the same small slab in the Meaford member of the Richmond, along Workman brook.

Plate No. VIII

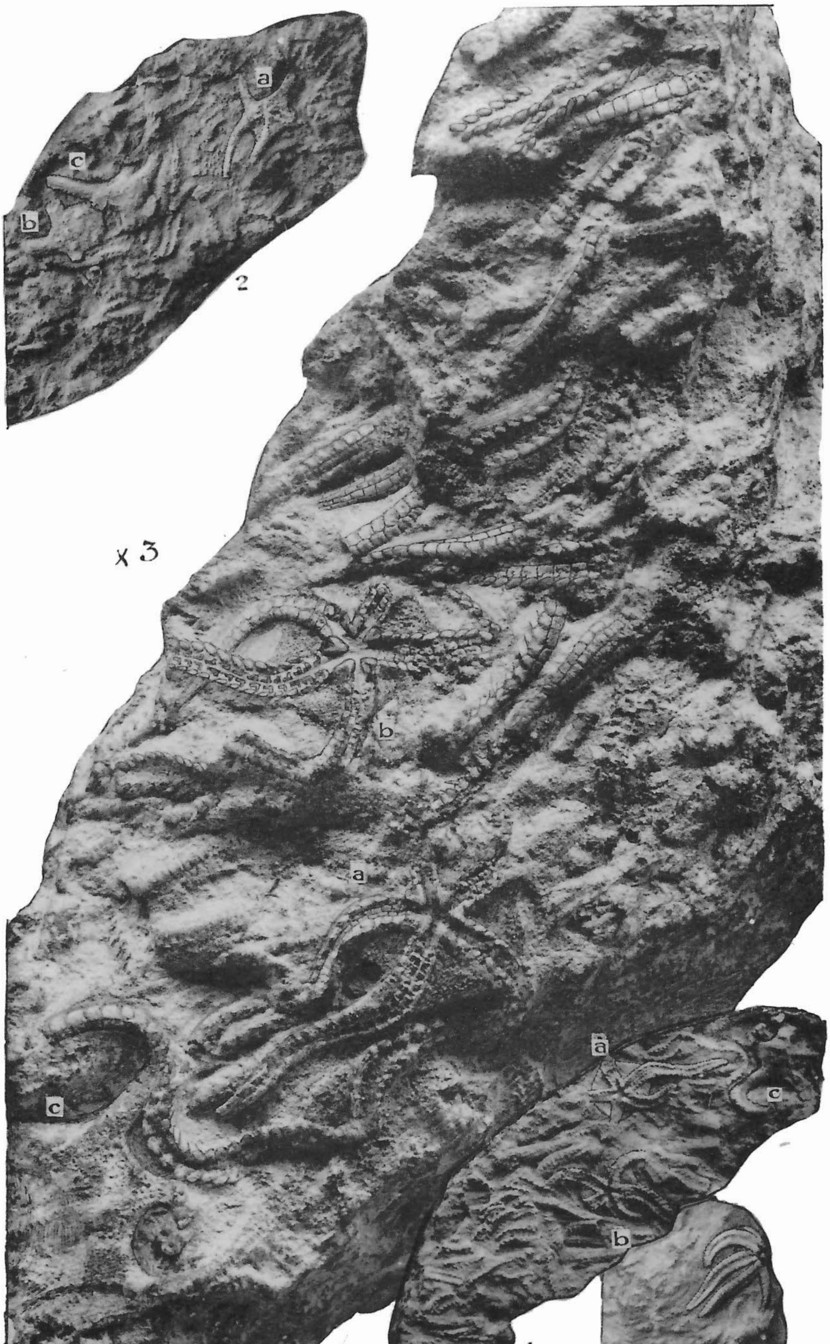


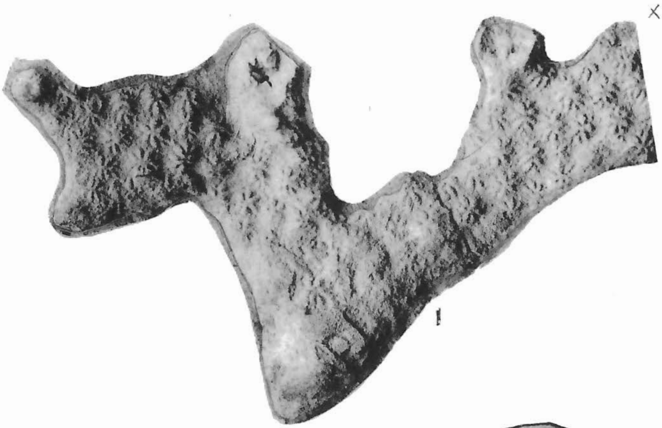
Plate IX

Figure 1. *Constellaria polystomella* Nicholson. Branching frond, showing stellate maculæ. Magnification: X 1⅓. No. 8550, from Clay cliffs. Richmond. (Page 106.)

Figure 2. *Rhombotrypa quadrata* (Rominger). Showing numerous small areas within which the cells are arranged in diagonally intersecting series. Magnification: X 3. No. 8551, Clay cliffs. Richmond. (Page 106.)

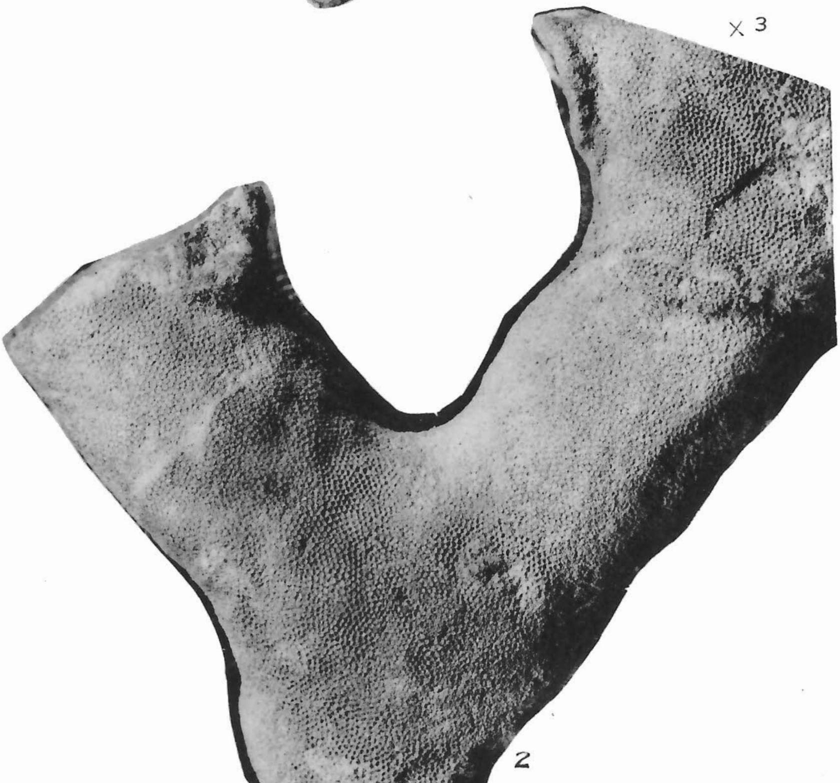
Plate No. IX

×1½



1

× 3



2

PLATE X

FIGURE 1. *Leptobolus insignis* Hall. Exterior of shell. Magnification: X 8. Middleville, New York; Utica slate. Palæontology of New York, 8, pt. 1, 1892, pl. 3, fig. 3. (Page 107.)

FIGURE 2. *Lingula rectilateralis* Emmons. Pedicle valve. Lorraine, New York, associated with *Triarthrus* in the Utica slate. Palæontology of New York, 1, 1847, pl. 79, fig. 1*a*. (Page 107.)

FIGURE 3. *Lingula curta* Conrad. Pedicle valve. Middleville, New York, Trenton. Palæontology of New York, 1, 1847, pl. 30, fig. 6 *b*. (Page 107.)

FIGURE 4. *Schizocrania filosa* Hall. Brachial valve attached to *Rafinesquina alternata*. Magnification: X 2. Cincinnati, Ohio, Maysville formation. Palæontology of New York, 8, pt. 1, 1892, pl. 4 G, fig. 22. (Page 108.)

FIGURE 5. *Trematis millepunctata* Hall. *a*, brachial valve, partly exfoliated. *b*, pedicle valve with projecting top of brachial valve. *c*, profile of cast of interior of conjoined valves. Magnification: X 2. Cincinnati, Ohio, Maysville formation. Palæontology of New York, 8, pt. 1, 1892, pl. 4 G, figs. 6, 7, 8. (Page 107.)

FIGURE 6. *Pholidops cincinnatiensis* Hall. Upper valve. Magnification: X 4. Cincinnati, Ohio, Eden and Maysville formations. Palæontology of New York, 8, pt. 1, 1892, pl. 4 I, fig. 18. (Page 108.)

FIGURE 7. *Pholidops subtruncata* (Hall). Upper valve. Magnification: X 4. Lorraine, New York; Pulaski formation. Palæontology of New York, 8, pt. 1, 1892, pl. 4 I, fig. 19. (Page 108.)

FIGURE 8. *Crania scabiosa* Hall. Several specimens on a brachial valve of *Rafinesquina alternata*. Cincinnati, Ohio, Eden and Maysville. Palæontology of New York, 8, pt. 1, 1892, pl. 4 H, fig. 23. (Page 108.)

FIGURE 9. *Dalmanella* sp. *a*, pedicle valve. *b*, lateral view with pedicle valve on left. *c*, brachial valve. Cincinnati, Ohio, from an elevation of 250 feet above Ohio river, Mount Hope member, Maysville. Palæontology of Ohio, 1, 1873, pl. 8, figs. 2 *a*, *b*, *e*. (Page 109.)

FIGURE 10. *Hebertella occidentalis* Hall. *a*, brachial valve with a faint median depression near the beak. *b*, pedicle valve, with the top of the brachial valve. Cincinnati, Ohio, Maysville and Richmond. Bull. Denison Univ. 16, 1910, pl. 2, figs. 2 A, B. (Page 110.)

FIGURE 11. *Hebertella sinuata* Hall. Brachial valve. Cincinnati, Ohio, Maysville and Richmond. Bull. Denison Univ., 16, 1910, pl. 2, fig. 5. (Page 110.)

FIGURE 12. *Platystrophia clarksvillensis* Foerste. Brachial valve. Fort Ancient, Ohio, lower or Fort Ancient division, Waynesville member, Richmond. Bull. Denison Univ., 16, 1910, pl. 3, fig. 3. (Page 112.)

FIGURE 13. *Platystrophia versaillesensis* Foerste. Brachial valve. Versailles, Indiana, Liberty member, Richmond. Bull. Denison Univ., 16, 1910, pl. 4, fig. 11 B. (Page 112.)

FIGURE 14. *Glyptorthis insculpta* (Hall). Brachial valve. Oxford, Ohio, top of Waynesville member, Richmond. Palæontology of Ohio, 1, 1873, pl. 9, fig. 1 A. (Page 110.)

FIGURE 15. *Rhynchotrema increbescens* (Hall). Pedicle valve. Lexington, Kentucky, Bigby member, Trenton. Bull. Denison Univ., 14, 1909, pl. 7, fig. 10 B. (Page 125.)

FIGURE 16. *Rhynchotrema capax* (Conrad). *a*, brachial valve, showing also the top of the pedicle valve; *b*, lateral view with the brachial valve on the right. Palæontology of Ohio, 1, 1873, pl. 11, figs. 2 *a*, *d*. (Page 124.)

FIGURE 17. *Catazyga headi* (Billings). *a*, brachial valve and top of pedicle valve. *b*, lateral view with brachial valve on left. East of Ottawa, in Richmond. Palæontology of New York, 8, pt. 2, 1894, pl. 54, figs. 24, 25. (Page 128.)

FIGURE 18. *Catazyga* (*Orthonomaea*) *erratica* (Hall). *a*, pedicle valve. *b*, cast of interior of pedicle valve. *c*, cast of interior of brachial valve. Magnification: X 2. *a*, from Hamilton, *b*, *c*, from drift blocks in central and western New York. Lorraine. Palæontology of New York, 8, pt. 2, pl. 54, figs. 19, 20, 21. (Page 130.)

FIGURE 19. *Catazyga headi borealis* (Billings). Brachial valve and top of pedicle valve. Anticosti island, Richmond. Palæontology of New York, 8, pt. 2, 1894, pl. 54, fig. 31. (Page 129.)

FIGURE 20. *Zygospira kentuckiensis* James. *a*, brachial valve. *b*, lateral view, with brachial valve on left. *c*, pedicle valve. Oldham county, Waynesville member, Richmond. Palæontology of New York, 8, pt. 2, pl. 54, figs. 11, 15, 16. (Page 127.)

FIGURE 21. *Zygospira modesta* Hall. *a*, pedicle valve. *b*, brachial valve, enlarged. Cincinnati, Ohio, Eden, Maysville, and Richmond formations. Bull. Denison Univ. 16, 1910, pl. 2, figs. 15 A, B. (Page 127.)

Plate No. X

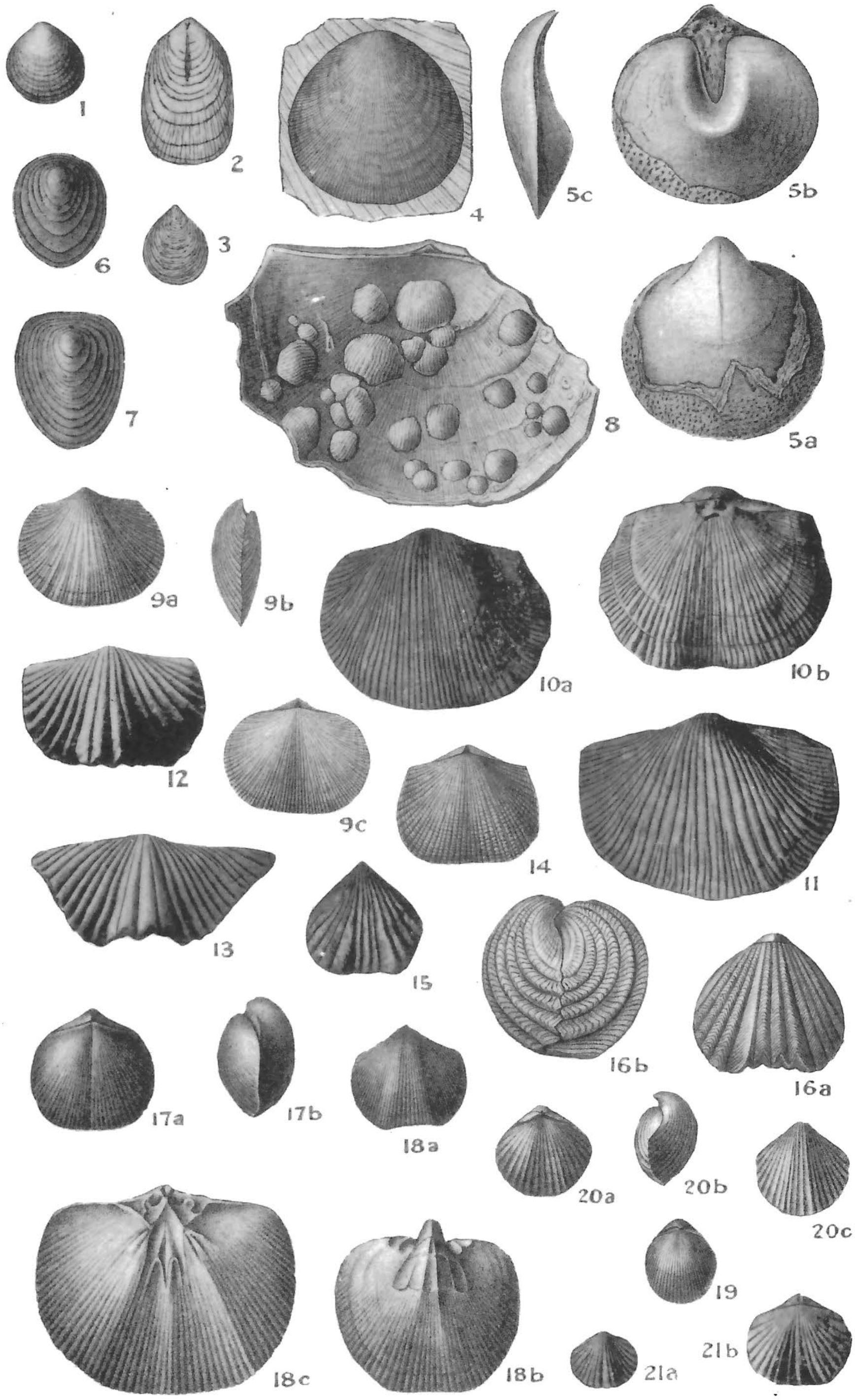

1
2
4
5c
5b
6
3
8
7
5a
9a
9b
10a
10b
12
9c
14
11
13
15
16b
16a
17a
17b
18a
20a
20b
20c
19
18c
18b
21a
21b

PLATE XI

FIGURE 1. *Pholidops subtruncata* (Hall). Specimens showing lower surface of several valves, illuminated so as to produce an appearance similar to the convex upper surface. Magnification: X 2. No. 8570, from Nicolet river. *Proetus* horizon, Lorraine. (Page 108.)

FIGURE 2. *Dalmanella manitoulinensis* sp. nov. Pedicle valve, magnification: X 2. No. 8526, Clay cliffs. Richmond. (Page 109.)

FIGURE 3. *Platystrophia clarksvillensis* Foerste. Brachial valve with rectangular postero-lateral angles. Magnification: X 1½. No. 8508, Clay cliffs. Richmond. (Page 112.)

FIGURE 4. *Lingula hyacinthensis* sp. nov. Probably both brachial valves; *a*, slightly distorted; *b*, strongly distorted. Magnification: X 3. No. 8589, from the river bed at St. Hyacinthe. *Cryptolithus* zone, Lorraine. (Page 107.)

FIGURE 5. *Rhynchotrema perlamellosum* (Whitfield). *a*, lateral view, with pedicle valve on left. *b*, brachial valve, with beak of pedicle valve projecting above its top. Magnification: X 1½. No. 8511, from the bluff west of Gore Bay village. Richmond. (Page 125.)

FIGURE 6. *Holtedahlina varsensis* sp. nov. Brachial valve with median fold; plications few and distant. Magnification: X 1½. No. 8572, from loose blocks along road a mile west of Vars. Richmond. (Page 124.)

FIGURE 7. *Holtedahlina sulcata moniquensis* var. nov. Pedicle valve. Magnification: X 1½. No. 8519, Snake island. Richmond. (Page 124.)

FIGURE 8. *Strophomena* sp. Cast of impression of brachial valve. Magnification: X 1½. No. 8571, Nicolet river. In the *Proetus* zone, Lorraine formation, 706 feet below the lowest horizon containing *Strophomena planumbona* and *Rhynchotrema perlamellosum*. (Page 122.)

Plate No. XI

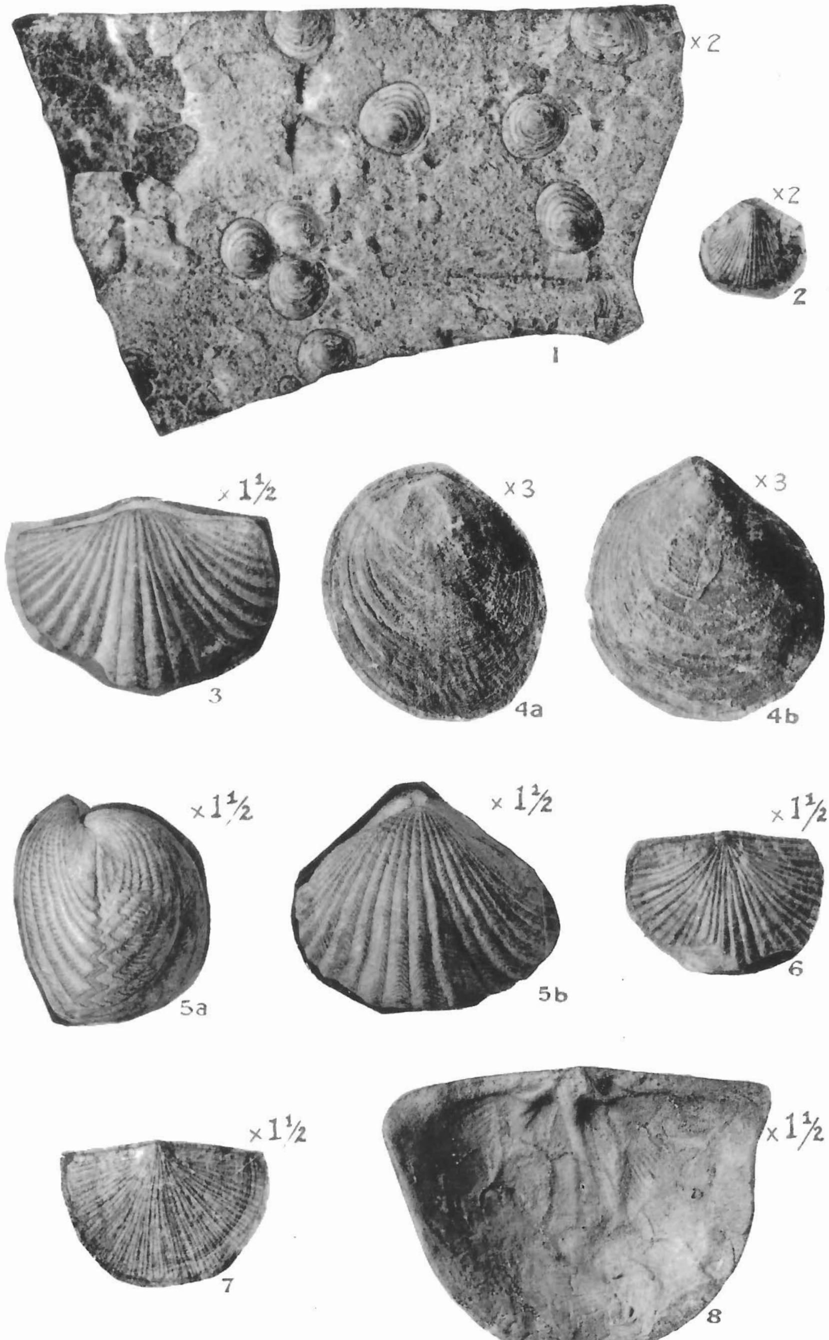


Plate XII

Figure 1. *Strophomena planumbona* (Hall). *a*, pedicle valve. *b*, brachial valve. *c*, interior of pedicle valve. Oxford, Ohio, Waynesville member, Richmond. Bull. Denison Univ., 17, 1912, pl. 8, figs. 1 A, C, E. (Page 117.)

Figure 2. *Strophomena nutans* Meek. *a*, interior of part of pedicle valve. No. 8127. *b*, *c*, *d*, interiors of pedicle valves. *a*, from Clay cliffs; *b*, *c*, *d*, from Oregonia, Ohio; Richmond. (Page 118.)

Figure 3. *Strophomena vetusta precursor* Foerste. *a*, brachial valve. *b*, pedicle valve. *c*, interior of pedicle valve. Clarksville, Ohio; Blanchester division, Waynesville member, Richmond. Bull. Denison Univ., 17, pl. 10, figs. 1 A, B, C. (Page 120.)

Figure 4. *Strophomena vetusta* (James). *a*, pedicle valve. *b*, interior of pedicle valve. *a*, from Blanchester, Ohio; *b*, from Dayton, Ohio; Whitewater member, Richmond. Bull. Denison Univ., 17, 1912, pl. 6, figs. 2, D, F. (Page 120.)

Figure 5. *Holtedahlina sulcata* (Verneuil). *a*, brachial valve. *b*, pedicle valve. Kagawong, Richmond. Bull. Denison Univ., 17, 1912, pl. 11, figs. 2 D, F. (Page 123.)

Figure 6. *Strophomena planumbona gerontica* Foerste. *a*, pedicle valve. *b*, hinge-area. *c*, lateral view with pedicle valve on right. *a*, *b*, from Madison, Indiana; *c*, from Gore Bay; Richmond. Bull. Denison Univ., 17, 1912, pl. 4, figs. 2 A, B, and pl. 11, fig. 6. (Page 117.)

Figure 7. *Strophomena hecuba* Billings. *a*, brachial valve. *b*, vertical section to show curvature of valves. Anticosti island; Richmond and Gamachian formations. Pal. Foss. 1, Geol. Surv., Can., 1865, p. 126, fig. 104. (Page 121.)

Figure 8. *Strophomena fluctuosa* Billings. *a*, brachial valve. *b*, vertical section to show curvature of valves. Anticosti island; Richmond. Pal. Foss. 1, Geol. Surv., Can., 1865, p. 123, fig. 102. (Page 119.)

Plate No. XII

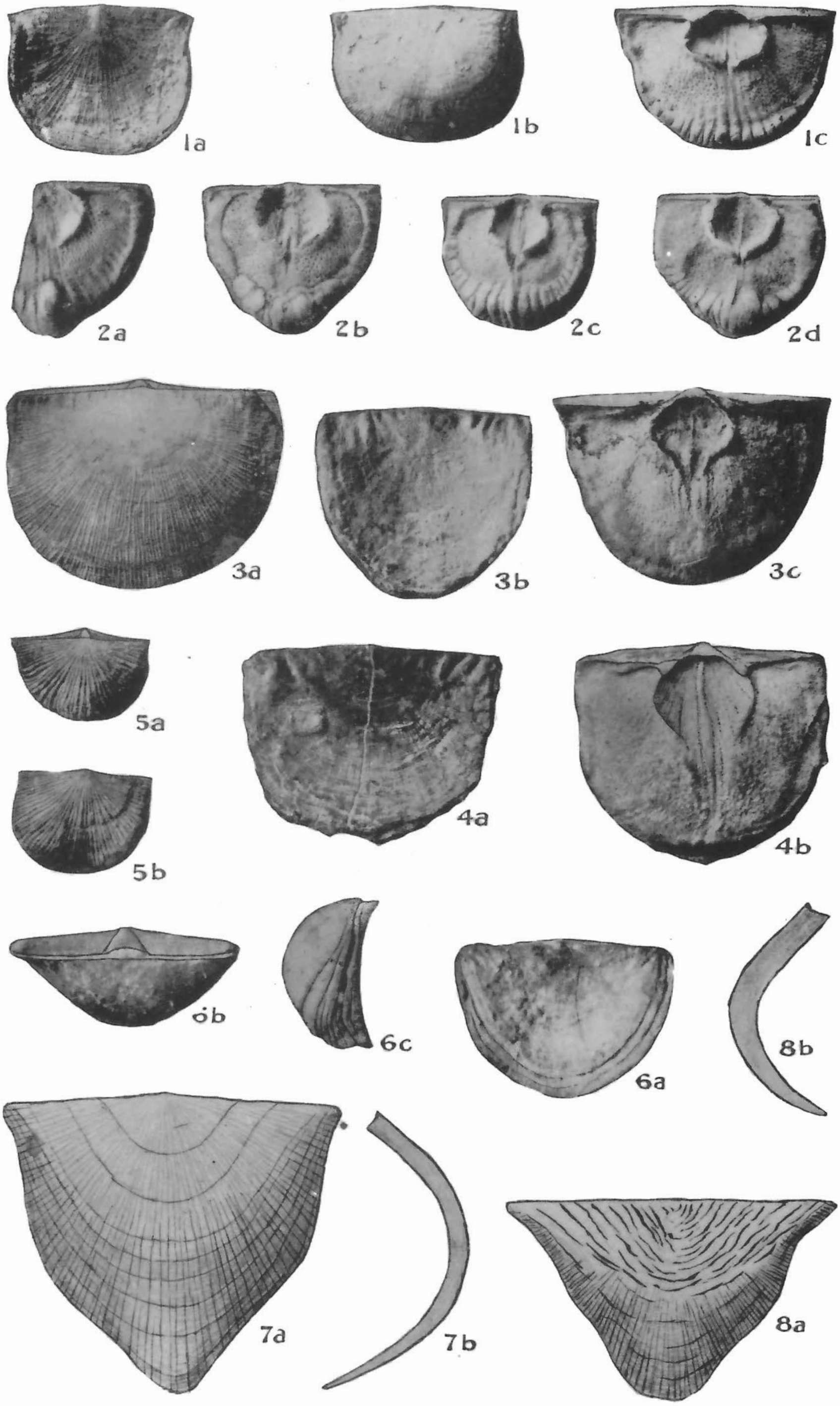


Plate XIII

Figure 1. *Strophomena huronensis* Foerste. *a, b, c, d, e*, interiors of pedicle valves. *f*, exterior of pedicle valve. *g*, interior of brachial valve. *h, j*, exteriors of brachial valves. Clay cliffs. Richmond. Bull. Denison Univ., 17, 1912, pl. 11, figs. 1 A, B, C, D, E, F, H, J, K. (Page 118.)

Figure 2. *Plectambonites curdsvillensis* Foerste. *a*, interior of brachial valve. *b*, brachial valve. *a*, Crow distillery, Woodford county, Kentucky; *b*, Mineral point, Wisconsin; in Trenton and Black River formations. Bull. Denison Univ., 17, 1912, pl. 10, fig. 15 B; and Palæontology of New York, 8, pt. 1, 1892, pl. 15, fig. 25. (Page 113.)

Figure 3. *Plectambonites rugosus clarksvillensis* Foerste. Interior of pedicle valve. Weisburg, Indiana. Whitewater member, Richmond. Bull. Denison Univ., 17, 1912, pl. 10, fig. 7 D. (Page 113.)

Figure 4. *Plectambonites plicatellus* (Ulrich). *a*, numerous shells, some with valves spread open. *b*, one of the shells enlarged. Covington, Kentucky. Fulton member, base of Eden formation. Palæontology of New York, 8, pt. 1, 1892, pl. 15 A, figs. 34, 35. (Page 114.)

Figure 5. *Strophomena neglecta* (James). *a*, interior of pedicle valve. *b*, brachial valve. *a*, from Stonington, Michigan; *b*, from Blanchester, Ohio; Richmond. Ottawa Naturalist, 31, 1917, pl. 5, fig. 11; and Bull. Denison Univ., 17, 1912, pl. 5, fig. 1 A. (Page 121.)

Figure 6. *Rafinesquina alternata* (Emmons). *a*, pedicle valve. *b*, brachial valve. *c*, vertical section to show curvature of the conjoined valves. Cincinnati, Ohio. In the Eden, Maysville, and Richmond formations. Originally described from the Trenton. Palæontology of New York, 8, pt. 1, 1892, pl. 8, figs. 7, 9. (Page 114.)

Plate No. XIII

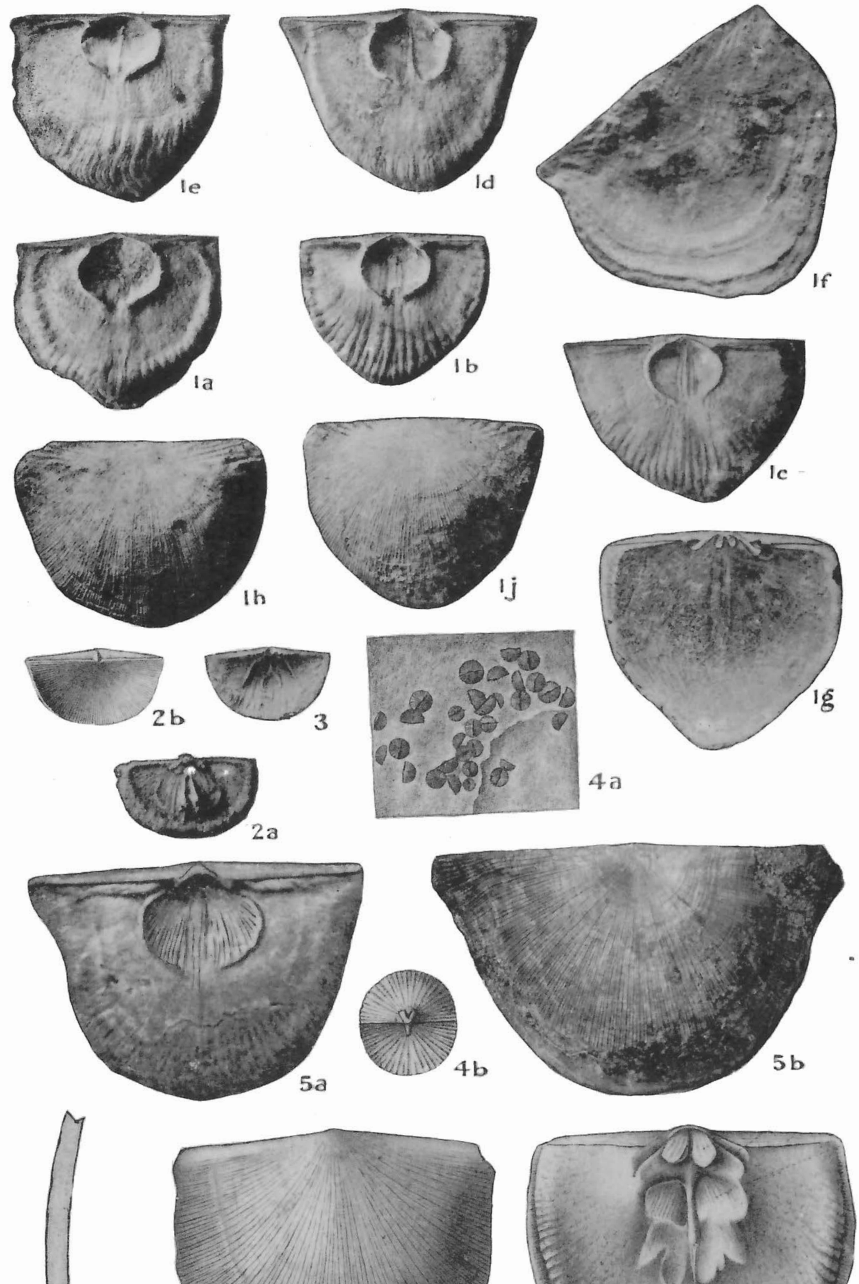


Plate XIV

Figure 1. *Rafinesquina mucronata* Foerste. Inner surfaces of pedicle valves, showing oblique wrinkling along the hinge-line. Magnification: X 3. *a*, No. 8574, Nicolet river; *Proetus* zone of the Lorraine. *b*, No. 8575, Chambly basin, Richelieu river, below the dam; *Proetus* zone of the Lorraine. (Page 115.)

Figure 2. *Leptæna moniquensis* sp. nov. Pedicle valve. Magnification: X 1½. No. 8559, Nicolet river, 150 feet below the top of the *Cryptolithus* zone of the Lorraine. (Page 116.)

Figure 3. *Leptæna moniquensis* sp. nov. *a*, *b*, casts of interiors of pedicle valves, showing outline of muscular areas; *c*, exterior of pedicle valve. *a*, *b*, Magnification: X 1½, *c*, X 3. Don Valley brick-yard. *Cryptolithus* zone of the Lorraine. (Page 116.)

Figure 4. *Plectambonites rugosus manitoulinensis* var. nov. *a*, *b*, pedicle valves; *c*, interior of brachial valve; *d*, interior of pedicle valve; outlines restored in *b*, *c*, and *d*. Magnification: X 2. No. 8557, 2 miles northeast of Gore Bay village; Richmond. (Page 113.)

Figure 5. *Strophomena vetusta* (James). Brachial valves, showing characteristic vertical wrinkling along the hinge-line. Magnification: X 1½. No. 8556, 3 miles south of Little Current, along east and west road; Richmond. (Page 120.)

Plate No. XIV

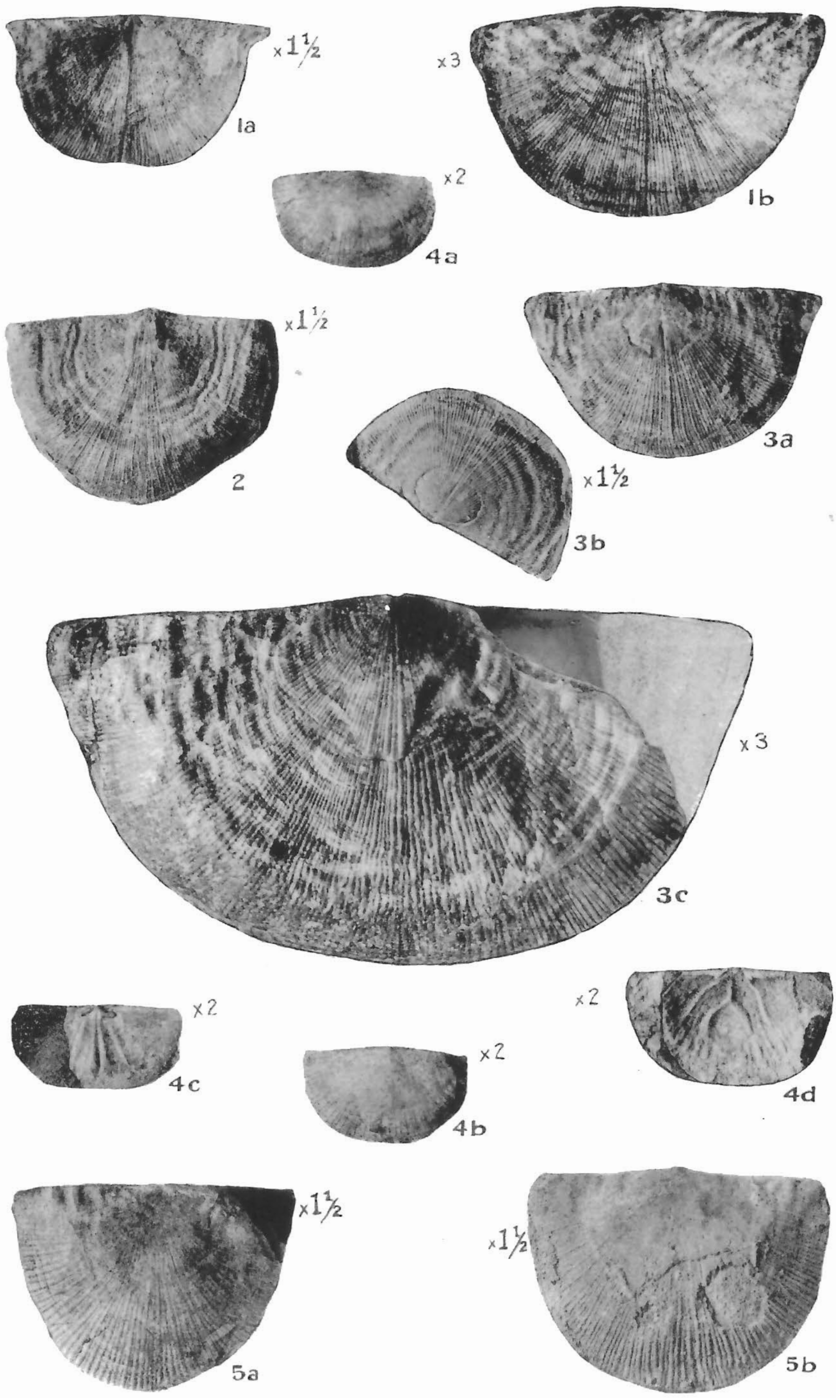


PLATE XV

FIGURE 1. *Zygospira kentuckiensis* James. *b*, brachial valves; *f*, pedicle valves. Magnification: X 1½. No. 8513, Nicolet river. In the highest fossiliferous layers of the Waynesville member of the Richmond. (Page 127.)

FIGURE 2. *Zygospira kentuckiensis* James. *a*, brachial valve, with beak of pedicle valve projecting about it; *b*, pedicle valve with median groove slightly wider than the rest; the four median plications at about the same elevation. Magnification: X 2. No. 8512, Clay cliffs; Richmond. (Page 127.)

FIGURE 3. *Zygospira meafordensis* sp. nov. *a*, *b*, exterior and interior of brachial valves; interiors showing the bilobed crural process. *c*, pedicle valve; six instead of four plications tend to rise to about the same level along the median part of the valve. Magnification: *a*, *c*, X 2; *b*, X 3. No. 8514, found 4 miles northwest of Meaford, in section VIII, lot 24, Queenston member, Richmond. (Page 128.)

FIGURE 4. *Zygospira kentuckiensis* var. Intermediate form, resembling *Zygospira meafordensis*. *a*, brachial valve; *b*, *c*, pedicle valves, differing in outline. Magnification: X 2. No. 8506. Clay cliffs; Richmond. (Page 127.)

FIGURE 5. *Rhynchotrema pulchellum* sp. nov. *a*, pedicle valve, with a faint median depression; *b*, *c*, brachial valves, with beak of pedicle valve projecting above the latter. Magnification: X 2. No. 8590, Snake island; Richmond. (Page 126.)

FIGURE 6. *Catazyga erratica* (Hall). *a*, ventral valve, exposing the interior toward the beak, where the shell is exfoliated; *b*, exterior of another ventral valve; both figures show median flattening of the elevated part of the valve. From Weston, northwest of Toronto; Lorraine; *a*, collected below the bridge opposite the middle of Weston; *b*, presented by E. J. Whittaker. (Page 130.)

FIGURE 7. *Rhynchotrema* (?) *tamarackensis* sp. nov. *a*, type, a fragment of the largest and best preserved valve, with the apical part missing. *b*, a small fragment presenting several specimens, suggesting a rather acute beak, but poorly preserved. Magnification: X 1¾. From Tamarack point, 10 miles southwest of Little Current; Sheguiandah member. (Page 126.)

Plate No. XV

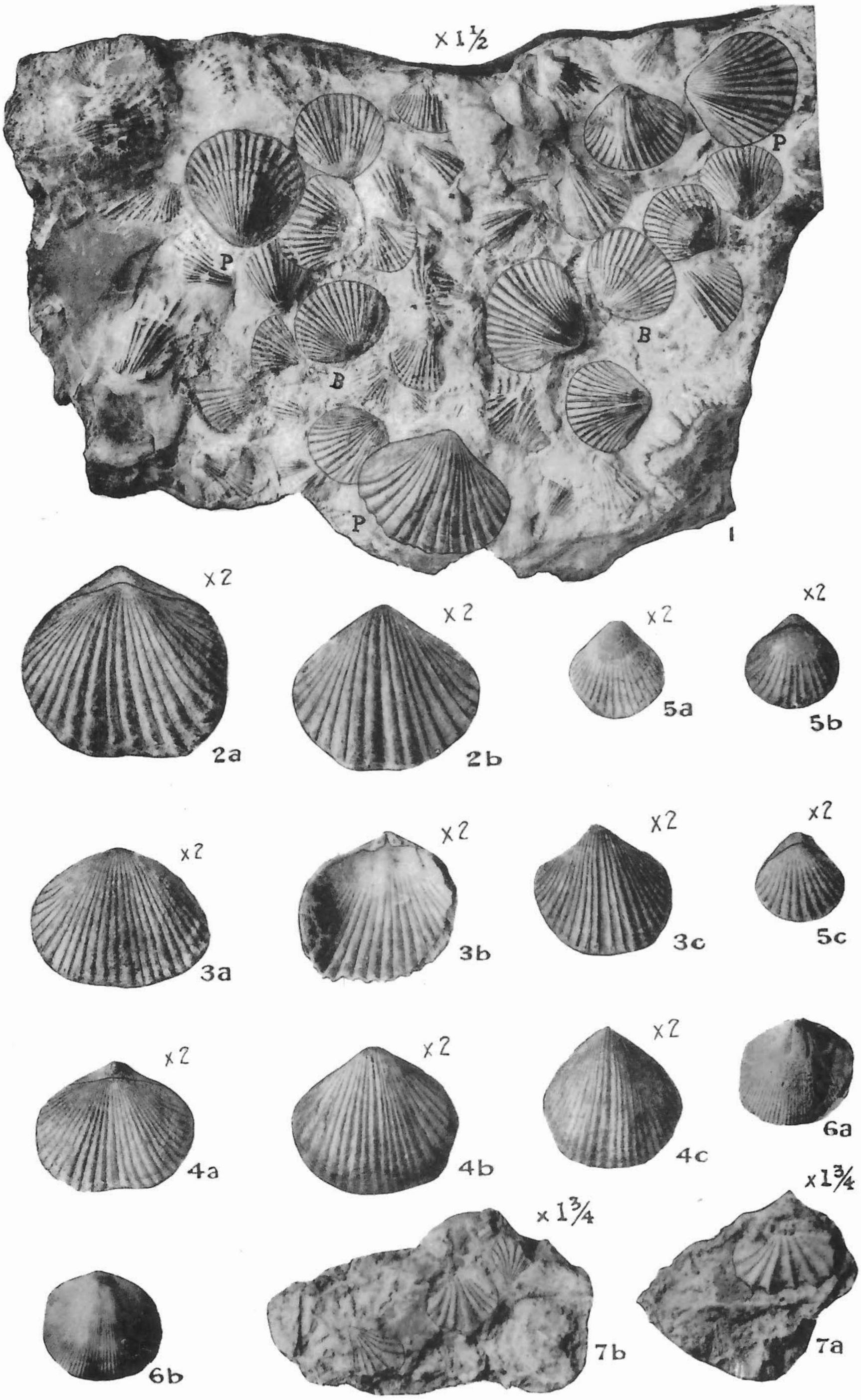

x 1½
P
P
B
B
P
1
x 2
2a
x 2
2b
x 2
5a
x 2
5b
x 2
3a
x 2
3b
x 2
3c
x 2
5c
x 2
4a
x 2
4b
x 2
4c
6a
x 1¾
x 1¾
6b
7b
7a

Plate XVI

Figure 1. *Ctenodonta cingulata gorensis* var. nov. Interior of right valve, showing hinge-area, lower outline of shell restored from traces of striæ. Magnification: X 2. No. 8484, found 1·5 miles northwest of Gore Bay village. Richmond. (Page 138.)

Figure 2. *Ctenodonta iphigenia* Billings. Interiors of right valves, hinge-areas imperfectly preserved. Magnification: X 1½. *a*, No. 8479, 2 miles northeast of Gore Bay village, along road following top of bluff. *b*, No. 8480, in gully north of Manitowaning. Richmond. (Page 133.)

Figure 3. *Ctenodonta* cf. *madisonensis* Ulrich. *a*, *b*, right and left valves. Magnification: X 2. No. 8483, Clay cliffs. Richmond. (Page 135.)

Figure 4. *Ctenodonta* cf. *madisonensis* Ulrich. *a*, right valve; *b*, fragment of left valve showing part of the hinge-area; original outline of shell indicated. Magnification: X 2. No. 8482, half a mile south of Clay cliffs, in Sheguiandah, Lorraine. (Page 135.)

Figure 5. *Ctenodonta chambliensis* sp. nov. *a*, cast of inner surface of left valve, with impression of posterior part of hinge-area, and indications of surface striæ; *b*, right valve. Magnification: X 2. *a*, No. 8471, Chambly Canton, Richelieu river, below the dam, Lorraine, *Proetus* zone. *b*, No. 8472, Nicolet river. Lorraine, *Proetus* zone. (Page 136.)

Figure 6. *Ctenodonta hyacinthensis* sp. nov. Left valve, with traces of posterior part of hinge-area. Magnification: X 3. No. 8586. St. Hyacinthe, in river bed, below the dam. In *Cryptolithus* zone, Lorraine. Collected by Robert Harvie. (Page 136.)

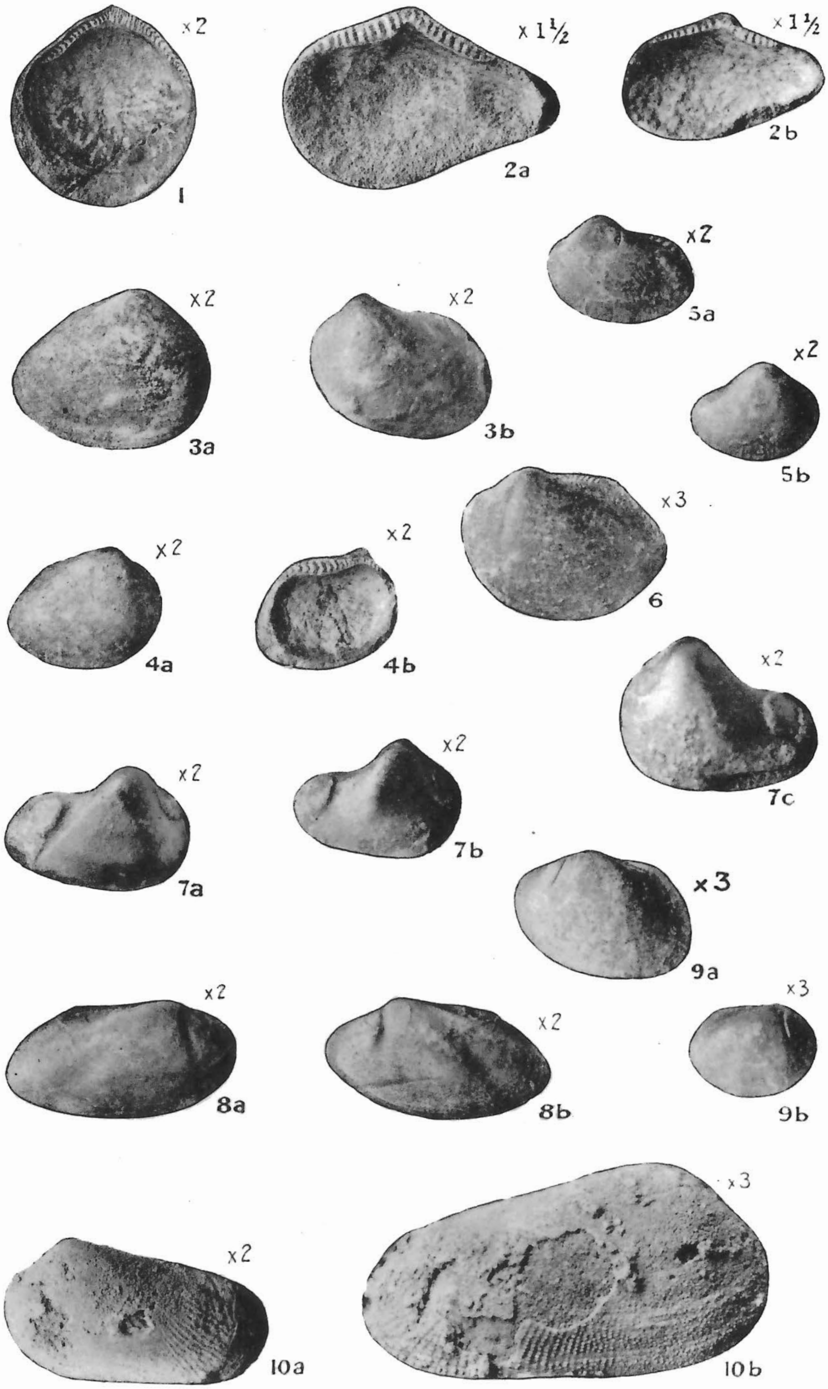
Figure 7. *Ctenodonta albertina* Ulrich. *a*, *b*, interiors of right valves, showing muscular impressions; *c*, left valve. Magnification: X 2. No. 8470, Snake island. Richmond. (Page 134.)

Figure 8. *Clidophorus postvolutus* sp. nov. *a*, *b*, right and left valves. Magnification: X 2. No. 8476, Nicolet river. *Cryptolithus* zone, Lorraine. (Page 140.)

Figure 9. *Clidophorus brevis* sp. nov. *a*, *b*, left and right valves. Magnification: *a*, *c*, X 3. No. 8586 *a*, *b*, from river bed below dam at St. Hyacinthe. *Cryptolithus* zone, Lorraine. (Page 141.)

Figure 10. *Rhytimya kagawongensis* Foerste. *a*, *b*, left and right valves, showing radiating rows of granules along the lower posterior part. Magnification: *a*, X 2. *b*, X 3. No. 8449, 2 miles southwest of Kagawong; Richmond. (Page 200.)

Plate No. XVI



x2
1
x 1½
2a
x 1½
2b
x2
3a
x2
3b
x2
5a
x2
5b
x3
6
x2
4a
x2
4b
x2
7a
x2
7b
x2
7c
x3
9a
x2
8a
x2
8b
x3
9b
x2
10a
x3
10b

Plate XVII

Figure 1. *Cuneamya elliptica* Miller. Left valve. Cincinnati, Ohio. McMillan division, Maysville. Jour. Cincinnati Soc. Nat. Hist., 4, 1881, pl. 8, Fig. 3. (Page 132.)
Figure 2. *Cuneamya neglecta* (Meek). Left valve. Clinton county, Ohio. Waynesville member, Richmond. Geol. Surv., Ohio, 2, 1875, pl. 2, fig. 11. (Page 131.)
Figure 3. *Cuneamya scapha* Hall and Whitfield. Left valve. Near Waynesville, Ohio. Waynesville member, Richmond. Geol. Surv., Ohio, Pal. 2, 1875, pl. 2, fig. 12. (Page 131.)
Figure 4. *Ortonella hainesi* (Miller). *a*, interior of left valve. *b*, right valve. Richmond, Indiana. Whitewater member, Richmond. Geol. Surv., Ohio, 7, 1893, pl. 53, figs. 9, 11. (Page 149.)
Figure 5. *Ctenodonta albertina* Ulrich. *a*, left valve. *b*, hinge view. Clarksville, Ohio. Waynesville member, Richmond. Geol. Minnesota, 3, 1894, pl. 42, figs. 76, 77. (Page 134.)
Figure 6. *Ctenodonta madisonensis* Ulrich. *a*, left valve. *b*, anterior view. Madison, Indiana. Arnheim member, Richmond. Geol. Minnesota, 3, 1894, pl. 42, figs. 65, 66. (Page 135.)
Figure 7. *Ctenodonta filistriata* Ulrich. *a*, cast of interior of right valve. *b*, hinge view of left valve. Covington, Kentucky. Eden. Geol. Minnesota, 3, 1894, pl. 599, figs. 44 *a*, *b*. (Page 134.)
Figure 8. *Ctenodonta simulatrix* Ulrich. *a*, cast of interior of right valve. *b*, hinge-area of right valve. Near Spring valley, Minnesota. Maquoketa member, Richmond. Geol. Minnesota, 3, 1894, pl. 42, figs. 74, 75. (Page 135.)
Figure 9. *Ctenodonta pectunculoides* (Hall). Interior of right valve. Cincinnati, Ohio. Eden and Maysville formations. Geol. Surv., Ohio, Pal. 2, 1875, pl. 1, fig. 24. (Page 137.)
Figure 10. *Ctenodonta cingulata* Ulrich. Interior of right valve. Magnification: X 2. At Marble Hill, Indiana, Waynesville member, Richmond. Geol. Surv., Ohio, 7, 1893, pl. 48, fig. 11. (Page 138.)
Figure 11. *Clidophorus neglectus* Hall. *a*, *b*, *c*, *d*, four views of the same specimen, the shell having been removed from the left side. *e*, oblique view of cast of hinge-area showing the teeth. Magnification: X 6. *f*, an unusually large valve. In Lafayette county, Wisconsin; at Dubuque and Graff, Iowa. Maquoketa member, Richmond. Geol. Minnesota, Pal. 3, 1894, pl. 42, figs. 20 to 25. (Page 141.)
Figure 12. *Clidophorus planulatus* (Conrad). Left valve. Turin, New York. Pulaski. Palæontology of New York, 1, 1847, pl. 82, fig. 7 *d*. (Page 138.)
Figure 13. *Whitella obliquata* Ulrich. Left valve. Blanchester and Waynesville, Ohio. Waynesville member, Richmond. Geol. Minnesota, 3, pt. 2, 1894, pl. 40, fig. 31. (Page 153.)
Figure 14. *Whitella sterlingensis* (Meek and Worthen). *a*, left valve. *b*, hinge view. Sterling, Illinois. Maquoketa member, Richmond. Geol. Minnesota, 3, pt. 2, 1894, pl. 41, figs. 27, 28. (Page 154.)

Plate No. XVII

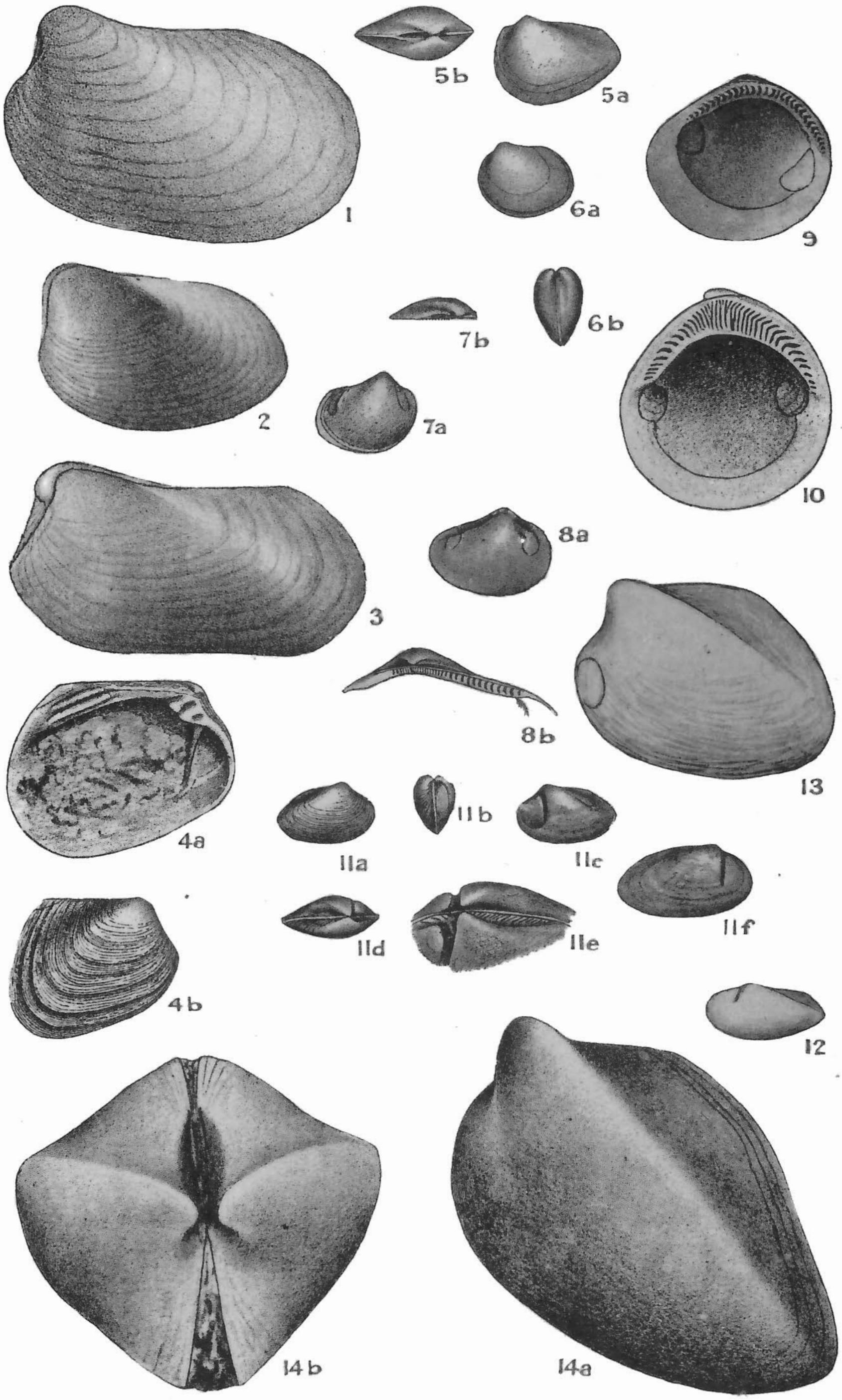


Plate XVIII

Figure 1. *Cyrtodonta ponderosa* Billings. Type specimen. *a*, right valve; *b*, view perpendicular to hinge-line; *c*, anterior side, viewed parallel to hinge-line. No. 2081, Clay cliffs. Richmond. (*See also* Plate XXXVIII, figure 1 *a*, *b*.) (Page 142.)

Figure 2. *Cyrtodonta ponderosa* Billings. *a*, right valve; *b*, view perpendicular to hinge-line; *c*, anterior side, viewed parallel to hinge-line. No. 8552, Clay cliffs. Richmond; collector, M. Y. Williams. (Page 142.)

Figure 3. *Cyrtodonta ponderosa perobliqua* var. nov. Right valve, defective along umbonal ridge, but showing outline very well. No. 8498 C, 2 miles southwest of Kagawong. Richmond. (Page 143.)

Plate No. XVIII

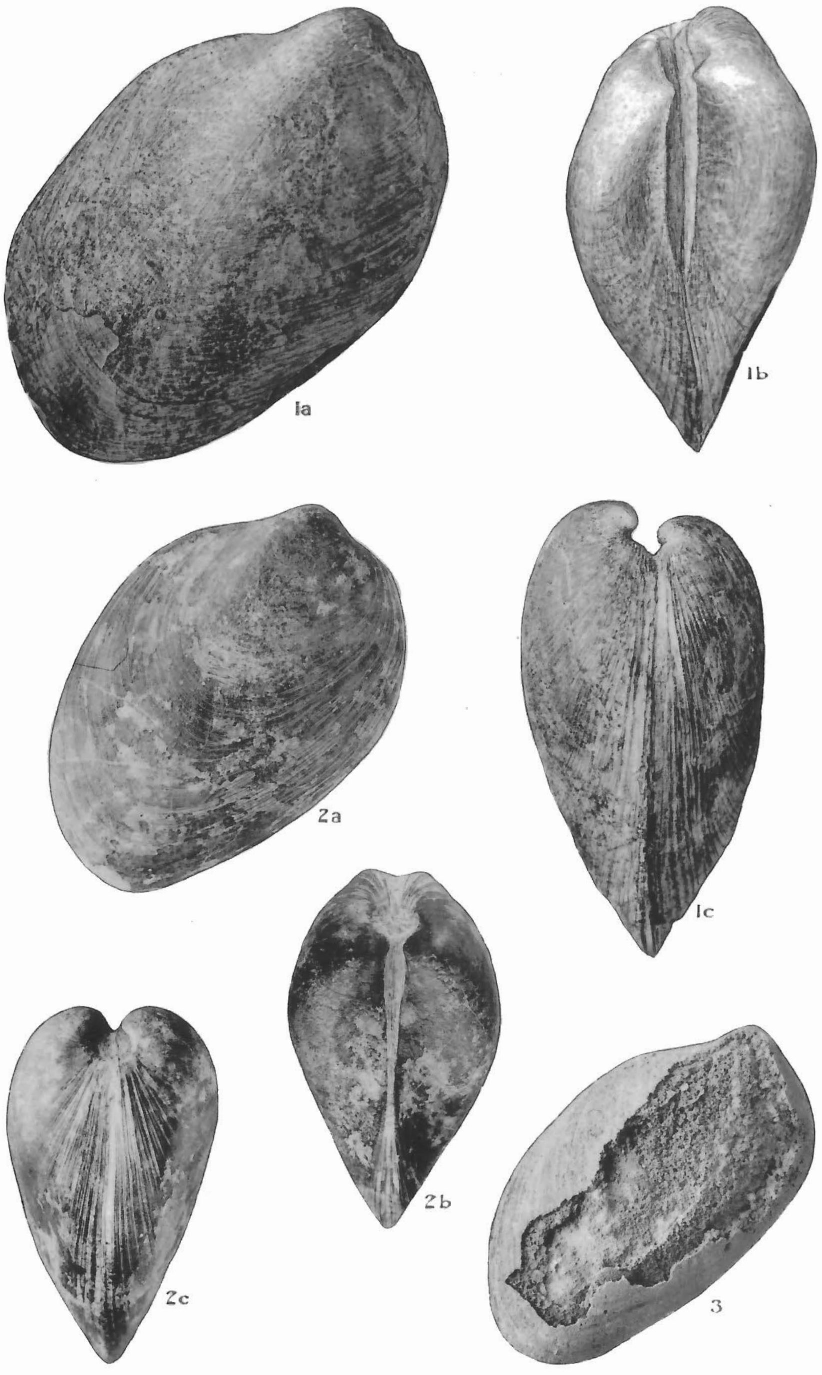


Plate XIX

Figure 1. *Cyrtodonta ponderosa perobliqua* var. nov. *a*, *b*, left valves, with lower posterior outline restored; in *b* only a few of the teeth well developed. *c*, right valve, showing hinge-area, teeth, and anterior muscle depression; most of the outline drawn in so as to indicate the relative position of the parts figured in the complete valve. No. 8498 A, B, D, from 2 miles southwest of Kagawong. Richmond. (Page 143.)

Figure 2. *Cyrtodonta ovalis* sp. nov. Right valve, showing hinge-area, teeth, and anterior muscle impression. Beak not exposed properly, and its outline may be in error. No. 8499, 4 miles southwest of Little Current, on road southwest of Indian village. Richmond. (Page 143.)

Figure 3. *Cyrtodonta exigua* sp. nov. *a*, left valve; *b*, cardinal view of same; *c*, interior of same, showing anterior teeth and muscle scar. *d*, upper anterior part of another left valve, showing anterior teeth and muscle scar. Outlines restored as indicated. No. 8453 A, B, C, D, from 2 miles northwest of Gore Bay village. Richmond. (Page 144.)

Figure 4. *Cyrtodonta kagawongensis* sp. nov. Left valve showing only the lower margin of the hinge-area, also teeth and muscle impression at the anterior margin, but not the striated part of the hinge-area nor the beak. Two miles southwest of Kagawong, on road to Gore Bay. Kagawong member, Richmond. (Page 144.)

Figure 5. *Ortonella* (?) *stewarti* sp. nov. Right valve, similar in outline to the preceding, but with different dentition. Two miles southwest of Kagawong, on road to Gore Bay. Kagawong member, Richmond. (Page 149.)

Figure 6. *Ortonella* (?) *gorensis* sp. nov. Left valve, exterior, with concentric striæ indicating former outline. No. 8497 *c*, 2 miles northwest of Gore Bay. Kagawong member, Richmond. (Page 150.)

Plate No. XIX

Plate XX

Figure 1. *Vanuxemia bayfieldi* Billings. Left valve, showing hinge-area, teeth, and anterior muscle scar; only the cardinal outline preserved. Type specimen. No. 2084, Bayfield sound. Richmond. The specimen has suffered from the cleaning, especially the area directly above anterior teeth where the length of the teeth appears to have been prolonged artificially by tool marks. If this specimen be twisted until its beak and hinge-area agree in position with the specimen of *C. ponderosa perobliqua* represented by Plate XIX, figure 1*a*, the direction of the anterior teeth and the character of the anterior muscle scar of this specimen resemble those of the latter sufficiently to raise the inquiry as to whether they might not belong to the same species. (Page 144.)

Figure 2. *Vanuxemia kagawongensis* sp. nov. *a*, anterior side, viewed parallel to hinge-line; *b*, left valve; *c*, cardinal side, viewed perpendicular to hinge-line; *d*, interior of right valve of a different specimen, showing hinge-area, anterior teeth, and anterior muscle scar; outline of *d* restored as indicated. No. 8500, immediately north of Kagawong falls. Richmond. (Page 146.)

Figure 3. *Whitella securiformis* (?) Foerste. *a*, right valve, distorted by pressure; *b*, *c*, posterior part of hinge-area and posterior teeth of right valves of imperfect specimens; *d*, hinge-area of left valve, especially the anterior part; *e*, hinge-area and posterior teeth of left valve. Margins of valves restored as indicated. No. 8546, Nicolet River section. Richmond. (Page 150.)

Plate No. XX

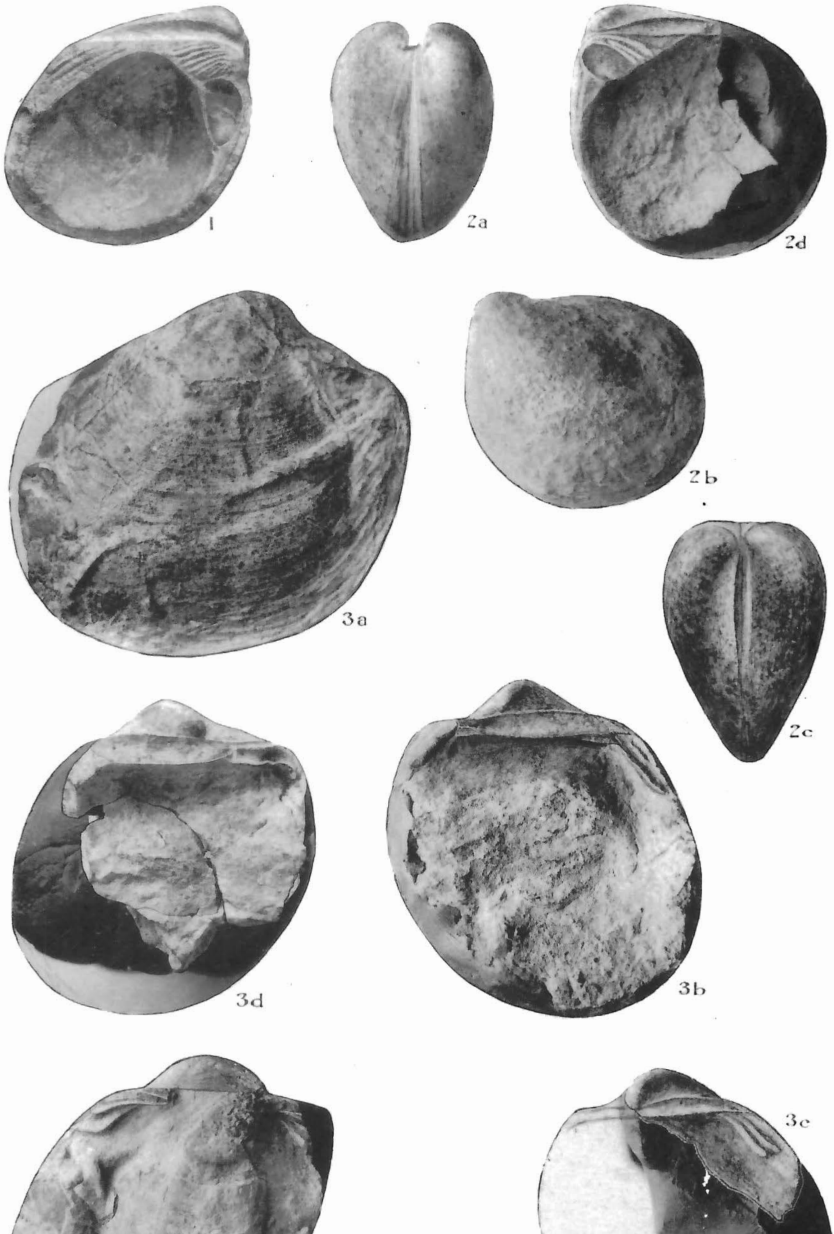


Plate XXI

Figure 1. *Whitella complanata moniquensis* var. nov. Right valve, in same rock with *Proetus chambliensis*. No. 8548, Nicolet River section. *Proetus* zone of Lorraine. (Page 153.)

Figure 2. *Whitella complanata moniquensis* var. nov. Right valve. No. 8547, Nicolet River section. In same slab with *Pterinea demissa*, *Pholadomorpha* zone, Lorraine. (Page 153.)

Figure 3. *Whitella complanata* Foerste. Right valve, with posterior margin restored. No. 8565, Nicolet River section. Richmond. (Page 152.)

Figure 4. *Whitella hindi* (Billings). *a*, left valve, with umbonal angle intensified by lateral distortion of shell, as seen in *b*, and *c*; *b*, cardinal view, perpendicular to hinge-area; *c*, anterior view, seen parallel to hinge-line. No. 2080, Toronto, probably from Humber valley. From *Pholadomorpha* zone of Lorraine. (Page 154.)

Figure 5. *Whitella huguesensis* sp. nov. *a*, left valve; *b*, cardinal view of same; *c*, right valve of another specimen. No. 8585 *a* , *b*, Yamaska river. In *Cryptolithus* zone of Lorraine. Collector, Robert Harvie. (Page 160.)

Plate No. XXI

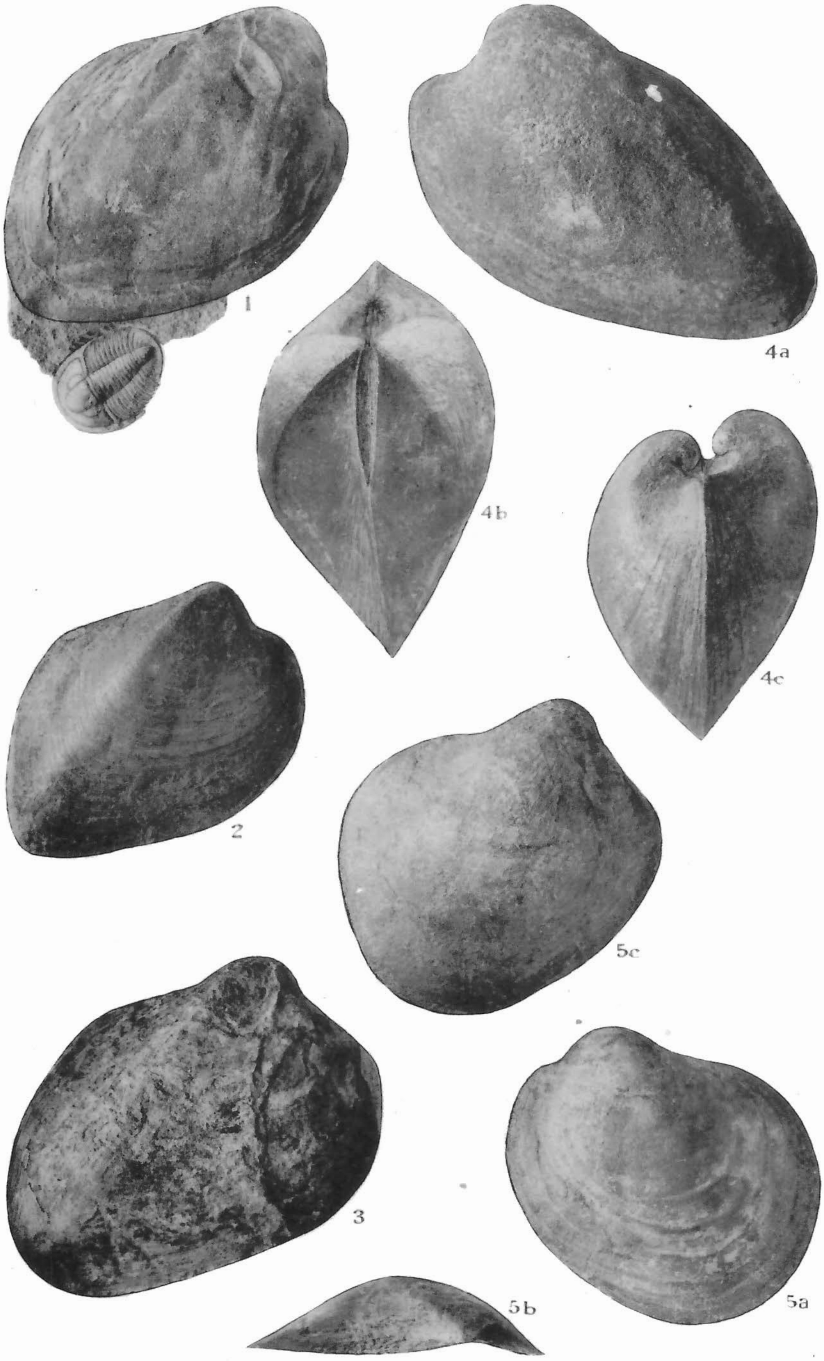


Plate XXII

Figure 1. *Whitella acutiumbonis* Stewart. *a*, right valve with upper posterior margin defective; body ornamented by five narrow, radiating grooves; *b*, left valve with three or four narrow grooves of which only the anterior is distinct. No. 1014, Royal Ontario Museum, from lower 8 feet at Don brick-yard. Specimen *a*, is the original of Plate I, figure 19, of Miss Stewart's paper. Both figures magnified X 2·7. (Page 158.)

Figure 2. *Whitella radiata* Stewart. *a*, right valve of a complete shell, with seven radiating grooves of which the anterior are slightly broader and deeper; upper posterior margin restored slightly; post-umbonal slope concave. *b*, cardinal view of same specimen, showing concave post-umbonal slopes at lower end of figure. No. 1002, Royal Ontario Museum, probably from Don brick-yard. Original of Plate III, figure 3, of Miss Stewart's paper. (Page 159.)

Figure 3. *Whitella* sp. *a*, *b*, right valves with faint traces of radiating grooves; post-umbonal slopes strongly concave as in preceding specimen; ventral outline unknown; valves probably incomplete, the entire valves being considerably larger. No. 1015, Royal Ontario Museum, lower 8 feet at Don brick-yard. Originals of Plate I, figures 20, 21, of Miss Stewart's paper. (Page 160.)

Figure 4. *Ctenodonta myalta* Stewart. Right valve, magnification: X 2·7. No. 1025 Royal Ontario Museum, from 15-foot level, Humbervale quarry, near Toronto. Original of Plate I, figure 7, of Miss Stewart's paper. Type of species.(Page 135.)

Figure 5. *Ctenodonta myalta* Stewart. Right valve, magnification: X 2·7. No. 1026, Royal Ontario Museum, from 8-foot level, Don brick-yard. Original of Plate I, figure 11, of Miss Stewart's paper. (Page 135.)

Figure 6. *Clidophorus obliquus* Stewart. Right valve, magnification: X 2·7; ventral margin infolded by pressure, so that exact height of valve is unknown; cardinal and posterior margins restored. No. 1018, Royal Ontario Museum, from 17-foot level in Humber River cut. Original of figure 9, Plate I, of Miss Stewart's paper. (Page 141.)

Figure 7. *Whitella parksi* Stewart. Right valve, with anterior and antero-ventral margins infolded moderately by pressure, obscuring the outline. No. 1013, Royal Ontario Museum, 6-foot level in Don brick-yard. Original of Plate I, figure 17, of Miss Stewart's paper. (Page 157.)

Figure 8. *Lyrodesma poststriatum elongatum* Stewart. Left valve. Reproduction of Plate IV, figure 4, of Miss Stewart's paper. No. 998, Royal Ontario Museum, from 17-foot level in Humber River cut. (Page 170.)

Figure 9. *Whitella impressata* Stewart. Three left valves; the surface of specimens *a* and *b* marked by faint, radiating grooves appearing lighter coloured in the figures, separating faint elevations of greater width of darker colour in the figures. Rather poor traces of similar colouring present along the anterior of the umbonal part of specimen *c*. No. 1011, Royal Ontario Museum, in the lower 8 feet of the Don brick-yard. Originals of Plate II, figures 2, 6, 3, of Miss Stewart's paper. (Page 156.)

Figure 10. *Byssonychia vera plana* Stewart. Left valve, with umbonal tip restored. No. 345, Royal Ontario Museum, from Humber river. Original of Plate I, figure 26, of Miss Stewart's paper. (Page 163.)

Figure 11. *Rhytimya colemani* Stewart. Right valve, magnification: X 2·7; anterior and lower posterior outlines restored; the traces of radiating lines of granules along the body of the valve are not visible in the figure and are visible only under cross-illumination in the specimen. No. 1031, Royal Ontario Museum, from the Don brick-yard. Original of Plate V, figure 13, of Miss Stewart's paper. (Page 198.)

Figure 12. *Whitella lata* Stewart. Left valve, with six faint radiating grooves on the body of the valve, appearing lighter coloured in the figure, separating broader lines of elevation which appear darker in the figure. No. 1012, Royal Ontario Museum, in the lower 8 feet of the Don brick-yard. Original of Plate III, figure 7, of Miss Stewart's paper. (Page 158.)

Figure 13. *Whitella torontoensis* Stewart. Right valve, with left valve of specimen strongly flattened and distorted by pressure, but not shown in figure. No. 1033, Royal Ontario Museum, probably from the Don valley. Original of Plate II, figure 5, of Miss Stewart's paper. (Page 155.)

The originals of the figures in this plate are in the Royal Ontario Museum, Toronto, Ontario, and are described in "The Stratigraphy and Paleontology of Toronto and Vicinity" by Beatrice Helen Stewart, in the 29th Ann. Rept., Ontario Dept. Mines, 29, pt. 6, 1920.

Plate No. XXII

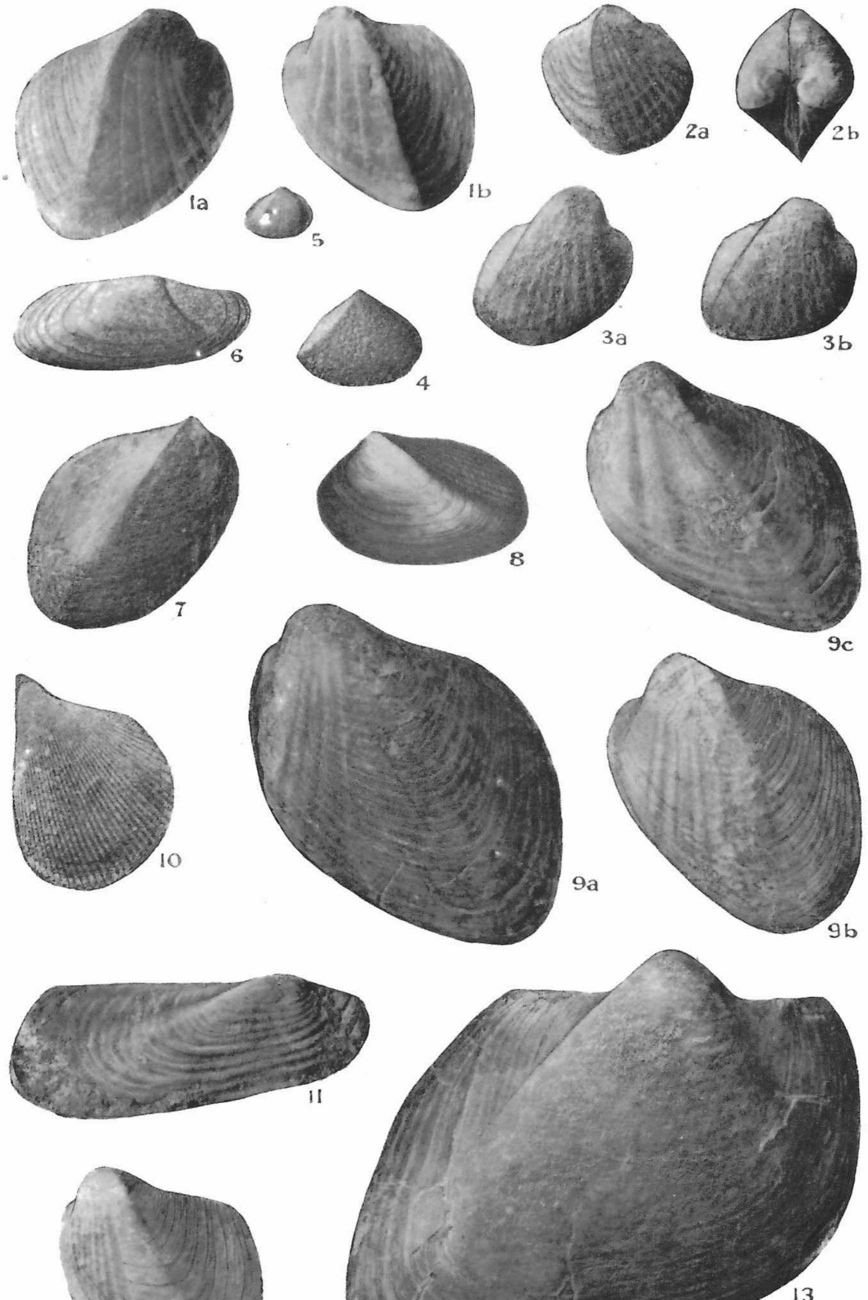


Plate XXIII

Figure 1. *Modiolopsis manitoulinensis* sp. nov. *a, b,* right valves. Clay cliffs. Richmond; Meaford member. (Page 180.)

Figure 2. *Modiolopsis vera* sp. nov. *a,* left valve; *b,* interior of right valve; *c,* interior of left valve; there is a tendency toward a tooth beneath the beak. Clay cliffs. Richmond; Meaford member. (Page 182.)

Figure 3. *Modiolopsis vera* sp. nov. *a,* right valve; *b,* cardinal view of same; *c, d,* two right valves. No. 8518 A, B, C, D, 2 miles southwest of Kagawong. Richmond; types of the species. Kagawong member. (Page 182.)

Figure 4. *Modiolopsis brevantica* Foerste. *a,* left valve; *b,* cardinal view perpendicular to hinge-line; *c,* anterior view, parallel to hinge-line. No. 8450, Clay cliffs. Richmond; Meaford. (Page 182.)

Figure 5. *Modiolopsis borealis* sp. nov. Left valve. Clay cliffs. Richmond; Meaford member. (Page 178.)

Figure 6. *Modiolopsis manitoulinensis* sp. nov. *a,* right valve, type of the species; *b,* hinge of right valve. Clay cliffs. Richmond; Meaford member. (Page 180.)

Figure 7. *Modiolopsis hyacinthensis* sp. nov. Left valve. No. 8473, from river bed at St. Hyacinthe, below the dam. *Cryptolithus* zone, Lorraine. (Page 177.)

Figure 8. *Orthodesma canaliculatum consimilis* var. nov. Cast of interior of left valve, showing anterior muscle impression, and also oblique lines crossing the pallial line. No. 8455, Workman creek. Richmond; Meaford member. (Page 193.)

Figure 9. *Modiolodon* (?) *kagawongensis* sp. nov. Left valve. Two miles southwest of Kagawong. Richmond; Kagawong member. (Page 177.)

Figure 10. *Ischyrodonta* (?) *manitoulinensis* sp. nov. Interior of right valve, showing hinge-area, teeth, and anterior muscle impression. No. 8495, 2 miles southwest of Kagawong. Richmond; Kagawong member. (Page 148.)

Figure 11. *Ischyrodonta unionoides westonensis* var. nov. Right valve. No. 2088, Weston. Lorraine; Pholadomorpha zone. Collector, Rev. J. M. Goodwillie. (Page 147.)

Figure 12. *Ischyrodonta unionoides westonensis* var. nov. *a,* right valve; *b,* cardinal view of same specimen. No. 2074, Weston. Lorraine; Pholadomorpha zone. Collector, Rev. J. M. Goodwillie. (Page 147.)

Plate No. XXIII

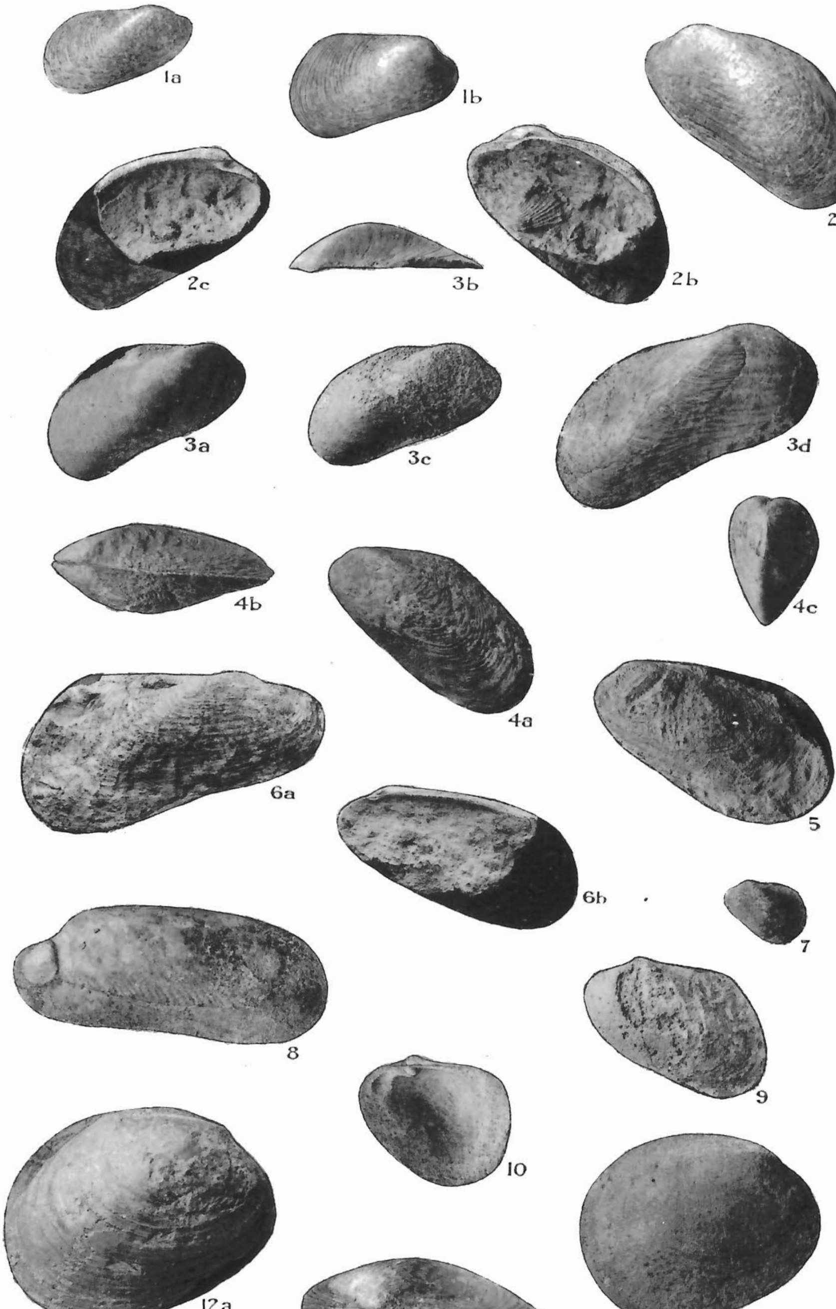


Plate XXIV

Figure 1. *Modiolopsis concentrica chambliensis* Foerste. Left valve, with anterior margin restored. No. 8563 *a*, Chambly basin, Richelieu river, below the dam. In *Proetus* zone, Lorraine. (Page 181.)

Figure 2. *Modiolopsis meafordensis* Foerste. Exterior-interior cast of left valve, showing anterior muscle scar and umbonal ridge. No. 2068, from Cape Rich, 8 miles north of Meaford, Ontario. From Lorraine-like strata; probably from lower part of Meaford member, Richmond, in the *Pholadomorpha* zone. Type. Collector, A. Murray. (Page 180.)

Figure 3. *Modiolopsis meafordensis* Foerste. *a, b*, casts of interiors of left valves, showing anterior muscle scars and traces of the pallial line. McLean hill, 2 miles south of Little Current. *Pholadomorpha* zone of the so-called Lorraine; probably in lower part of Meaford member, Richmond. (Page 180.)

Figure 4. *Modiolopsis borealis* Foerste. *a*, left valve, with concentric striæ on post-umbonal slope. *b, c*, two left valves, showing traces of long ridges on posterior part of hinge-area, for articulation; posterior and lower margins of *c* restored. *d, e*, two partly exfoliated valves showing the radiating striæ characteristic of the inner layers of the shell; umbonal ridge distinctly defined toward the beak. *f*, interior cast of two valves belonging to the same specimen; dorsal view. Three-quarters of a mile south of Clay cliffs. *Pholadomorpha* zone of the so-called Lorraine; possibly from lower part of Meaford member, Richmond. (Page 178.)

Figure 5. *Modiolopsis borealis postdeclivis* var. nov. *a, b*, two left valves, with strongly-defined mesial sinus and correspondingly distinct umbonal ridge, the posterior part curving downward as in *Modiolopsis concentrica*. From the same locality and horizon as the preceding. (Page 179.)

Plate No. XXIV

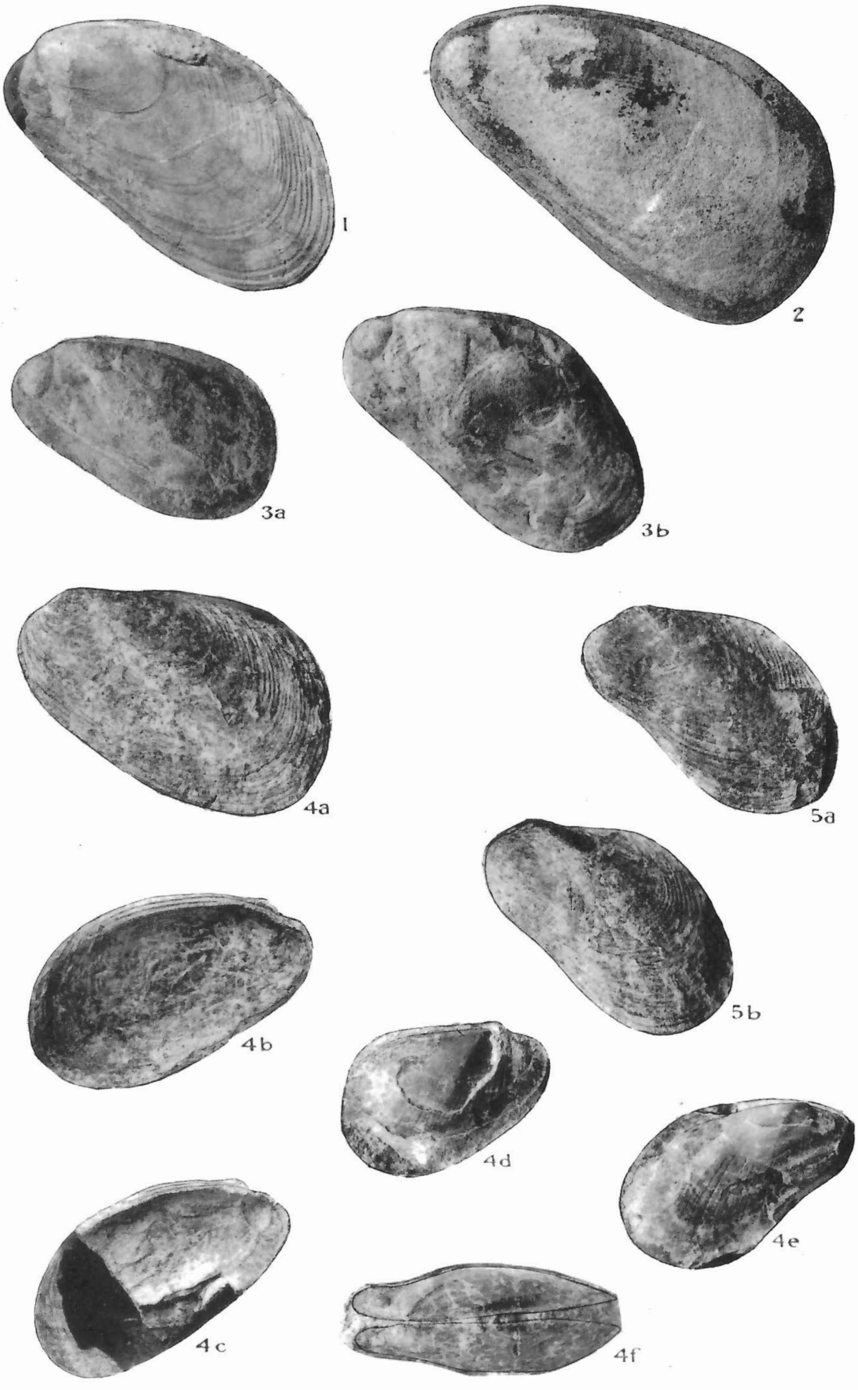


Plate XXV

Figure 1. *Cymatonota recta* Ulrich. Left valve. Newport, Kentucky. McMillan division, Maysville. Geol. Surv., Ohio, 7, 1893, pl. 55, fig. 8. (Page 175.)
Figure 2. *Cymatonota parallela* (Hall). Left valve. Pulaski, New York, Pulaski formation. Palæontology of New York, 1, 1847, pl. 82, fig. 7*c*. (Page 174.)
Figure 3. *Cymatonota semistriata* Ulrich. *a*, left valve. *b*, anterior part of same specimen. Magnification: X 2. Clarksville, Ohio. Waynesville member, Richmond. Geol. Surv., Ohio, 7, 1893, pl. 55, figs. 6, 7. (Page 176.)
Figure 4. *Orthodesma canaliculatum* Ulrich. *a*, cast of interior of right valve. *b*, hinge view of same. Waynesville, Ohio, Waynesville division, Richmond. Geol. Minnesota, 3, Pal., pt. 2, 1894, pl. 37, figs. 7, 8. (Page 193.)
Figure 5. *Psiloconcha inornata* Ulrich. Right valve. Cincinnati, Ohio. Bellevue member, Maysville. Geol. Surv., Ohio, 7, 1893, pl. 52, fig. 11. (Page 195.)
Figure 6. *Psiloconcha sinuata* Ulrich. Left valve. Cincinnati, Ohio. Bellevue member, Maysville. Geol. Surv., Ohio, 7, 1893, pl. 52, fig. 16. (Page 196.)
Figure 7. *Psiloconcha subovalis* Ulrich. Right valve. Morrow, Ohio, Bellevue member, Maysville. Geol. Surv., Ohio, 7, 1893, pl. 52, fig. 7. (Page 195.)
Figure 8. *Colpomya faba* (Emmons). Right valve. Watertown, New York, Trenton. Palæontology of New York, 1, 1847, pl. 35, fig. 6*a*. Page 172.)
Figure 9. *Modiolopsis anodontoides* (Emmons). Left valve. Lorraine, New York, in the sandstone, Pulaski. Palæontology of New York, 1, 1847, pl. 82, fig. 3*a*. (Page 178.)
Figure 10. *Lyrodesma poststriatum* (Emmons). *a*, right valve, *b*, hinge view of same, to show radiating striæ posterior to the beak. Magnification: X 1½ diameters. Weston. In the Lorraine. No. 2077, Geol. Surv., Can. (Page 169.)
Figure 11. *Modiopolis concentrica* Hall and Whitfield. *a*, cast of interior of left valve. *b*, exterior of left valve. Waynesville, Ohio. Waynesville member, Richmond. Geol. Minnesota, 3, Pal. pt. 2, 1894, pl. 37, figs. 15, 16. (Page 181.)
Figure 12. *Rhytimya compressa* Ulrich. Right valve. Cincinnati, Ohio. Fairmount member, Maysville. Geol. Surv., Ohio, 7, 1893, pl. 56, fig. 13. (Page 198.)
Figure 13. *Rhytimya oehana* Ulrich. Right valve. Cincinnati, Ohio. McMillan division, Maysville. Geol. Surv., Ohio, 7, 1893, pl. 56, fig. 1. (Page 199.)
Figure 14. *Rhytimya radiata* Ulrich. Right valve. Covington, Kentucky, Southgate member, Eden. Geol. Surv., Ohio, 7, 1893, pl. 56, fig. 10. (Page 199.)

Plate No. XXV

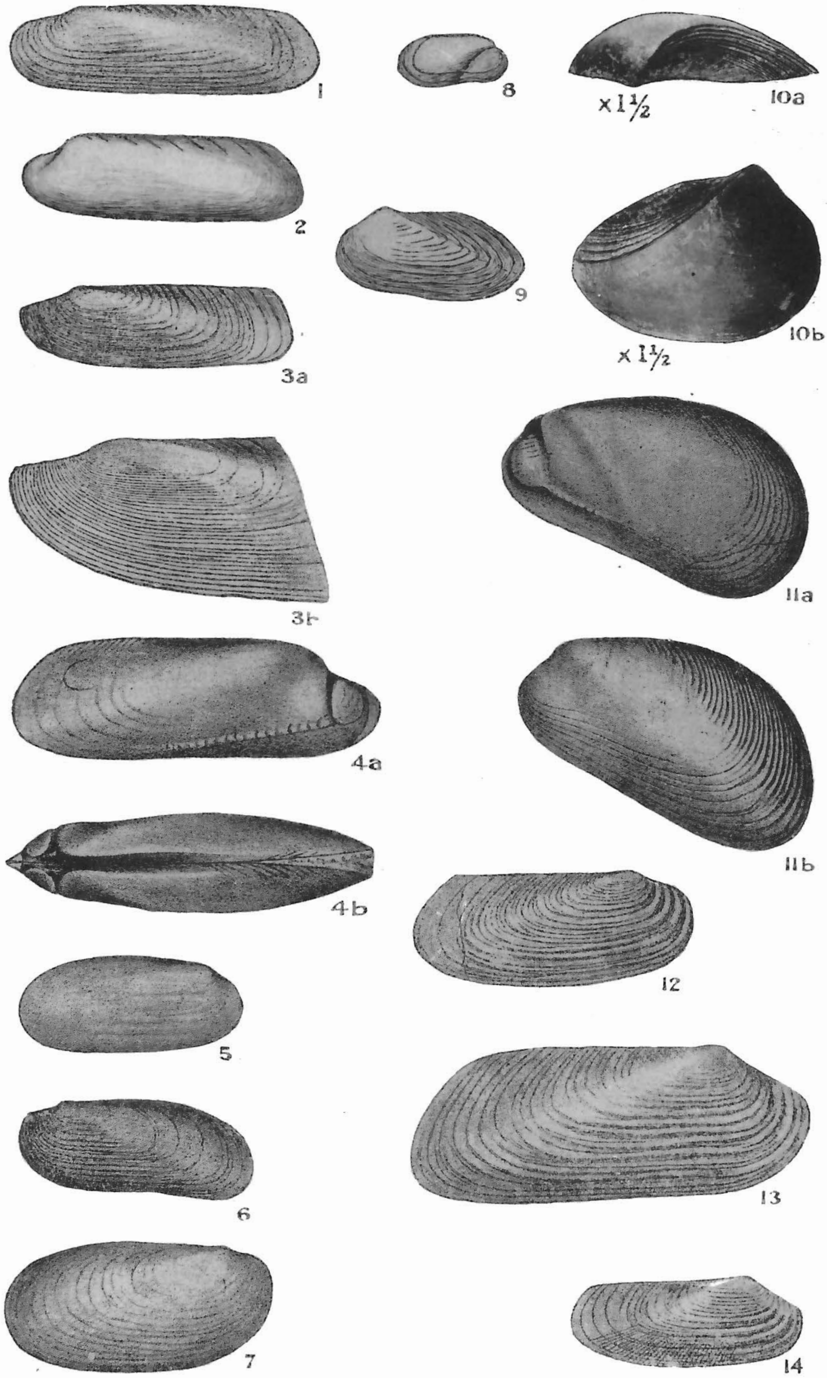


Plate XXVI

Figure 1. *Opisthoptera fissicosta* (Meek). Left valve. No. 2112, Hamilton, evidently an erratic specimen from some Richmond exposure. Collector, Mr. Turnbull. (Page 167.)

Figure 2. *Opisthoptera fissicosta* (Meek). Left valve, differing in outline from the preceding, No. 2111, Nottawasaga bay, probably from the vicinity of Cape Rich or Meaford. Richmond. Collector, A. Murray. (Page 167.)

Figure 3. *Pterinea* (*Caritodens*) *demissa* Conrad. Left valve with concentric markings showing variations in outline with increasing age. No. 8547, Nicolet River section. *Pholadomorpha* zone, Lorraine, 127 feet below the lowest horizon containing *Strophomena planumbona* and *Rhynchotrema perlamellosum*. (Page 161.)

Figure 4. *Clionychia curta* sp. nov. *a*, *b*, left valve, without the distinctly angulate anterior outline characteristic of the genus *Clionychia*. *c*, angulate specimen, suggesting the generic reference. *a*, No. 8475, from river bed at St. Hyacinthe, below the dam. *b*, *c*, No. 8588, collected by R. Harvie from the same locality. *Cryptolithus* zone, Lorraine. (Page 162.)

Figure 5. *Whitella securiformis* Foerste. Right valve. Type specimen. No. 8420, Huron river, several miles southwest of St. Jean Baptiste. Richmond. Collector, James Richardson. (Page 150.)

Figure 6. *Pterotheca harviei* sp. nov. Specimen with posterior margin indistinctly defined; wrinkled along posterior margin in a direction parallel to median line; median ridge preserved anteriorly; part of shell broken away, exposing transverse septum beneath, and its lateral attachment to lower side of shell. Outline restored. No. 8584, 2 miles northwest of St. Hugues. Collector, Robert Harvie. *Cryptolithus* zone, Lorraine. (Page 219.)

Plate No. XXVI

PLATE XXVII

FIGURE 1. *Byssonychia richmondensis* Ulrich. *a*, two valves of the same shell, only moderately displaced, anterior view showing byssal opening. *b*, beak and anterior half of right valve, with margin restored as indicated. No. 8515, east of Barrie Island bridge, Manitoulin island. Richmond. (Page 167.)

FIGURE 2. *Byssonychia borealis* sp. nov. *a*, left valve; *b*, anterior view of same specimen; *c*, left valve of another specimen; margins restored as indicated. Clay cliffs, Richmond. (Page 165.)

FIGURE 3. *Byssonychia radiata* (Hall). *a*, right valve; *b*, anterior view of another specimen. No. 8517, from a mile south of Clay cliffs. *Pholadomorpha* zone, Lorraine. (Page 164.)

FIGURE 4. *Byssonychia grandis* Ulrich. Cast of interior of left valve, showing impression of hinge-area. No. 2120, from some unknown locality on Nottawasaga bay, probably from Cape Rich area, north of Meaford. Collector, A. Murray. (Page 166.)

Plate No. XXVII

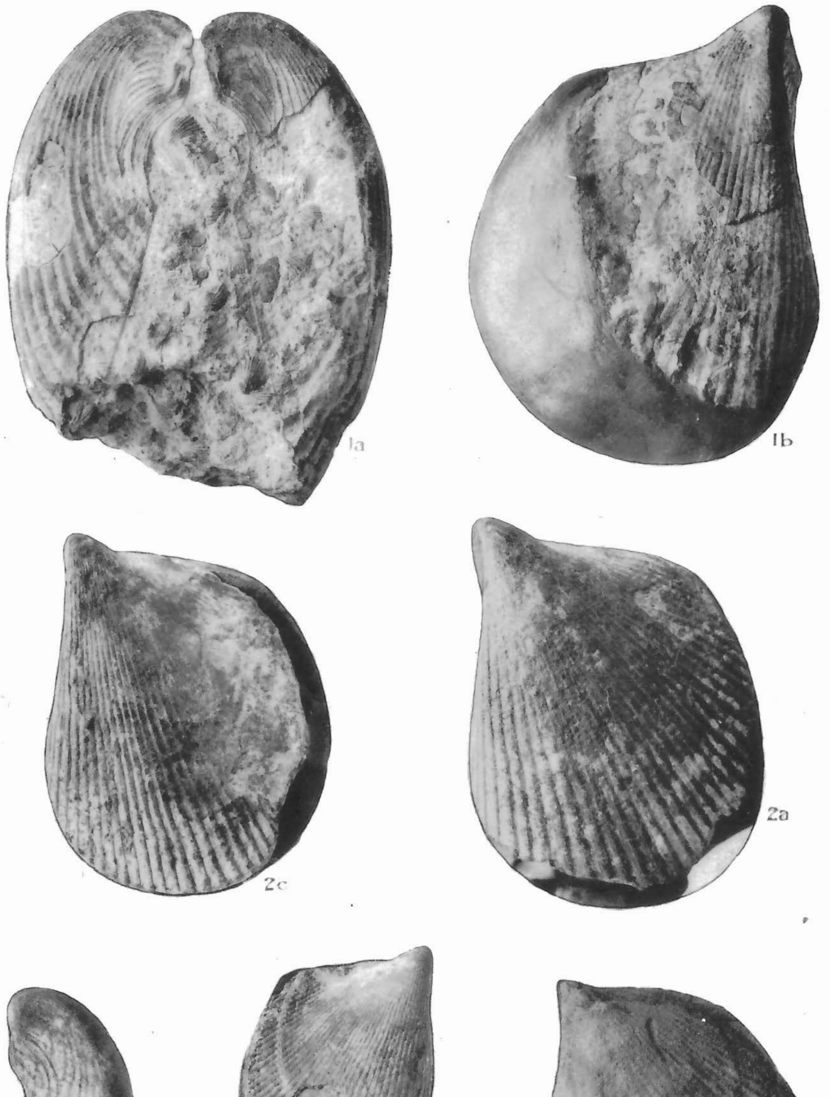


Plate XXVIII

Figure 1. *Byssonychia vera* Ulrich. *a*, left valve. *b*, anterior view. Newport, Kentucky, Eden. Geol. Surv., Ohio, 7, 1893, p. 629, figs. *a*, *b*. (Page 163.)

Figure 2. *Byssonychia praecursa* Ulrich. *a*, right valve. *b*, anterior view. Lorraine, New York, Pulaski. Geol. Surv., Ohio, 7, 1893, pl. 45, figs. 1, 2. (Page 167.)

Figure 3. *Byssonychia suberecta* Ulrich. *a*, right valve. *b*, anterior views of two valves. *a*, Waynesville, Ohio; *b*, Versailles, Indiana. Waynesville member, Richmond. Geol. Surv., Ohio, 7, 1893, pl. 45, figs. 13, 15. (Page 166.)

Figure 4. *Byssonychia richmondensis* Ulrich. *a*, right valve. *b*, anterior view. Richmond, Indiana. Whitewater member, Richmond. Geol. Surv., Ohio, 7, 1893, pl. 45, figs. 3, 4. (Page 167.)

Figure 5. *Byssonychia grandis* Ulrich. Left valve. Oxford, Ohio. Waynesville member, Richmond. Geol. Surv., Ohio, 7, 1893, pl. 46, fig. 6. (Page 166.)

Figure 6. *Byssonychia cultrata* Ulrich. Right valve. Waynesville, Ohio. Waynesville member, Richmond. Geol. Surv., Ohio, 7, 1893, pl. 45, fig. 5. (Page 166.)

Plate No. XXVIII

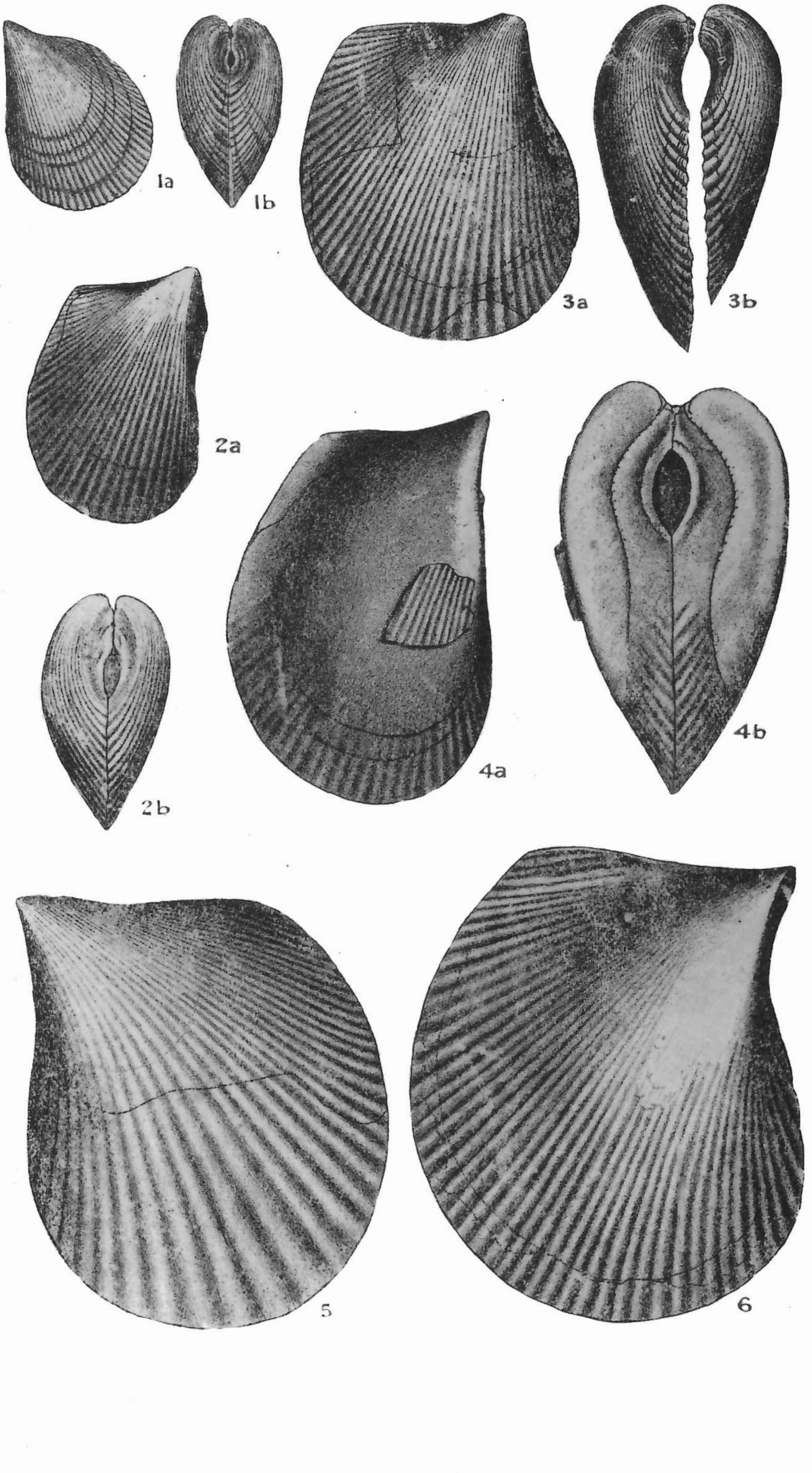


Plate XXIX

Figure 1. *Archinacella pulaskiensis* Foerste. *a*, viewed from above. *b*, lateral view of same. *Cryptolithus* horizon, Pulaski shale, several hundred yards west of railway bridge, Pulaski, New York. Original of Plate IV, figures 3 C, D. Bull. Sci. Lab. Denison Univ. 17, 1914. (Page 203.)

Figure 2. *Whitella complanata* Foerste. Left valve, with direction of hinge-line strongly oblique to horizontal line across the figure. Huron river. No. 8421. (Page 152.)

Figure 3. *Whitella goniumbonata* Foerste. Right valve. Huron river. No. 8426. (Page 156.)

Figure 4. *Orthodesma* (?) *postplicatum* (Foerste). Right valve. Huron river. No. 8424. (Page 191.)

Figure 5. *Orthodesma approximatum* Foerste. Right valve, exterior-interior cast, showing anterior muscle impression; defective posteriorly. Richelieu river at Chambly, in the *Proetus* zone, Lorraine. No. 8425. (Page 192.)

Figure 6. *Clidophorus praevolutus* Foerste. *a*, left valve; *b*, right valve; both figures magnified 2·7 diameters. Huron river. No. 8427. (Page 139.)

Figure 7. *Modiolodon poststriatus* Foerste. Right valve. From 1½ miles northwest of Vars. No. 8428. (Page 176.)

Figure 8. *Pholadomorpha chambliensis* Foerste. Right valve. Apparently from Chambly. No. 2069. (Page 198.)

Figure 9. *Cymatonota lenior* Foerste. · Left valve, with part of right valve visible above the hinge-line; with impression of anterior muscle. Huron river. No. 8422. (Page 176.)

Figure 10. *Pterinea* (*Caritodens*) *demissa* Conrad. Left valve, with anterior and posterior extremities near the hinge-line broken off, but with outlines restored. Huron river. No. 8429. (Page 161.)

Figure 11. *Rhytimya oehana* Ulrich. Left valve, defective near the anterior. Richelieu river at Chambly. From the *Proetus* zone, Lorraine. No. 8423. (Page 199.)

Figure 12. *Clidophorus praevolutus* Foerste. Left valve. Magnification: X 2·7. Type specimen. Richelieu river, near Chambly. No. 2079. (Page 139.)

Figure 13. *Clidophorus* cf. *planulatus*. Left valve. Magnification: X 2·7. Rome, New York. One of the specimens selected from the series numbered R-1232 in the State Museum at Albany, New York. (Page 138.)

Figure 14. *Cymatonota pholadis* Conrad. Two valves belonging to the same specimen, slightly separated in the same rock fragment, with their anterior ends directed toward the right. Richelieu river at Chambly. No. 2085. (Page 175.)

Figure 15. *Orthodesma prolatum* Foerste. Left valve. From the shore below Bécancour river, presumably along St. Lawrence river. No. 2144. (Page 194.)

Figure 1*a* and *b* on this plate are reproductions of figure 3 *c* and *d*, Plate IV, of the "Lorraine Faunas of New York and Quebec," published in the Bulletin of the Scientific Laboratories of Denison University, in 1914. All other figures correspond to the same numbers on Plate I of the same paper, but figures 6, 12, and 13 are enlarged.

Plate No. XXIX

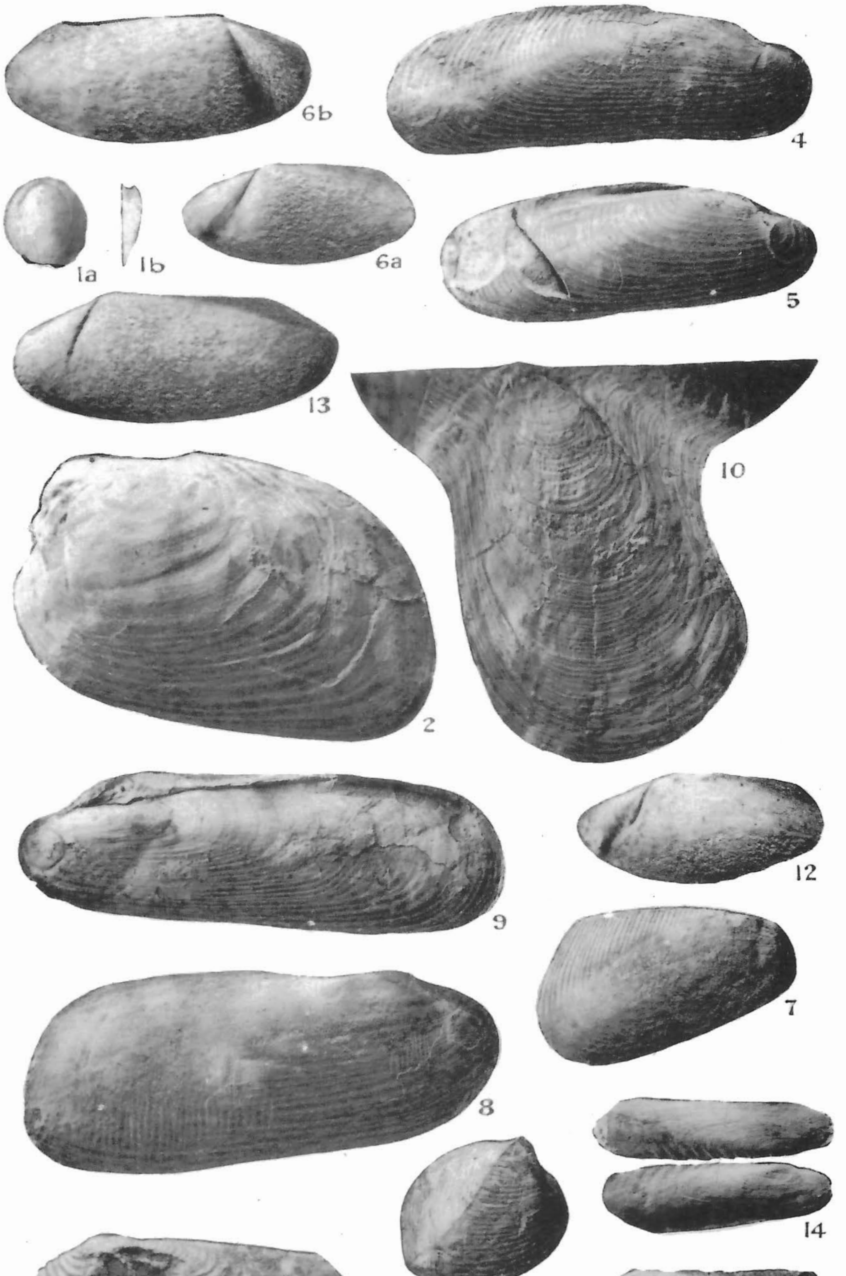


PLATE XXX

FIGURE 1. *Pterotheca pentagona* Foerste. Specimen showing lateral lines of attachment of the triangular septum to the lower side of the shell. That part of the shell overlying the septum, the marginal part on the right, and the crest of the carina anteriorly are missing. Richelieu river, near Chambly. No. 2155. Type. (Page 220.)

FIGURE 2. *Pterotheca pentagona* Foerste. Specimen exposing the septum as far as its anterior margin. Only a trace of the carina remains anteriorly. Most of the outline missing but restored in the figure; anterior margin along the carina unknown. From the top of *Leptæna* zone, Nicolet River section. No. 8409. (Page 220.)

FIGURE 3. *Pterotheca clochensis* sp. nov. Specimen showing lateral lines of attachment of the triangular septum to the lower side of the shell; lateral margin of the left side of the shell missing. Western shore of Cloche peninsula, north of Manitoulin island. In red clay shale of lower Lowville age. No. 8406. (Page 218.)

FIGURE 4. *Strophomena planumbona chambliensis* var. nov. Pedicle valve; type specimen. Richelieu river, at Chambly. No. 8404. (Page 118.)

FIGURE 5. *Strophomena planumbona chambliensis* var. nov. Brachial valve, showing exterior on right and part of cast of interior on left. From among a lot of specimens labelled as coming from Huron river. No. 8405. (Page 118.)

FIGURE 6. *Rafinesquina mucronata* Foerste. Pedicle valve, cast of interior, with right margin restored. From about a mile northwest of Vars. Original of Plate II, figure 7 A, of "Lorraine Faunas of New York and Quebec." Magnification: X 2·7. No. 8432. (Page 115.)

FIGURE 7. *Rafinesquina mucronata* Foerste. Pedicle valve, cast of interior. From about a mile northwest of Vars. Original of specimen in upper right hand corner of Plate II, figure 7 B, of "Lorraine Faunas of New York and Quebec." Magnification: X 2·7. No. 8432 *a*. (Page 115.)

FIGURE 8. *Lophospira beatrice* Foerste. Two specimens, types. Huron river. Specimen *a* is numbered 8417, specimen *b* is numbered 8417 *a*. (Page 214.)

FIGURE 9. *Psiloconcha sinuata borealis* Foerste. *a*, two valves belonging to the same specimen. No. 2087 with anterior ends directed toward the left. *b*, right valve No. 8411, selected as the type. Huron river. (Page 196.)

FIGURE 10. *Psiloconcha sinuata borealis* Foerste. Left valve. *Pholadomorpha* zone on Nicolet river. Original of Plate II, figure 9 C, of "Lorraine Faunas of New York and Quebec." No. 8412. (Page 196.)

FIGURE 11. *Colpomya faba pusilla* Foerste. Left valve. *Proetus* zone, Richelieu river. No. 8430. (Page 172.)

FIGURE 12. *Cuneamya scapha brevior* Foerste. Left valve. Huron river, near St. Jean Baptiste. No. 8407. (Page 132.)

FIGURE 13. *Technophorus quincuncialis* Foerste. Right valve. *a*, a small specimen showing distinctly all of outline except anterior part of upper margin. Quincuncial arrangement of pits shown distinctly by the specimen but is not seen in the figure. *b*, a larger specimen showing the quincuncial arrangement of the pits. Most readily detected about one-third of the height of the body above its base. Magnification: X 2·7. Richelieu river at Chambly. From a group of specimens numbered 8415, 8413, and 2076. (Page 249.)

FIGURE 14. *Pholadomorpha divaricata* Hall and Whitfield. Left valve, with impression of anterior muscle. Huron river, near St. Jean Baptiste. No. 2071. (Page 197.)

FIGURE 15. *Psiloconcha subovalis* Ulrich. *a*, right valve. *b*, cast of exterior of left valve, its concave surface throwing a deep shadow near the hinge-line. Huron river, near St. Jean Baptiste. No. 8408. (Page 195.)

FIGURE 16. *Pholadomorpha pholadiformis* Hall. Left valve with a trace of the anterior muscle impression. From 2 miles northeast of Gore Bay village, along the eastern shore of the bay. (Page 197.)

Plate No. XXX

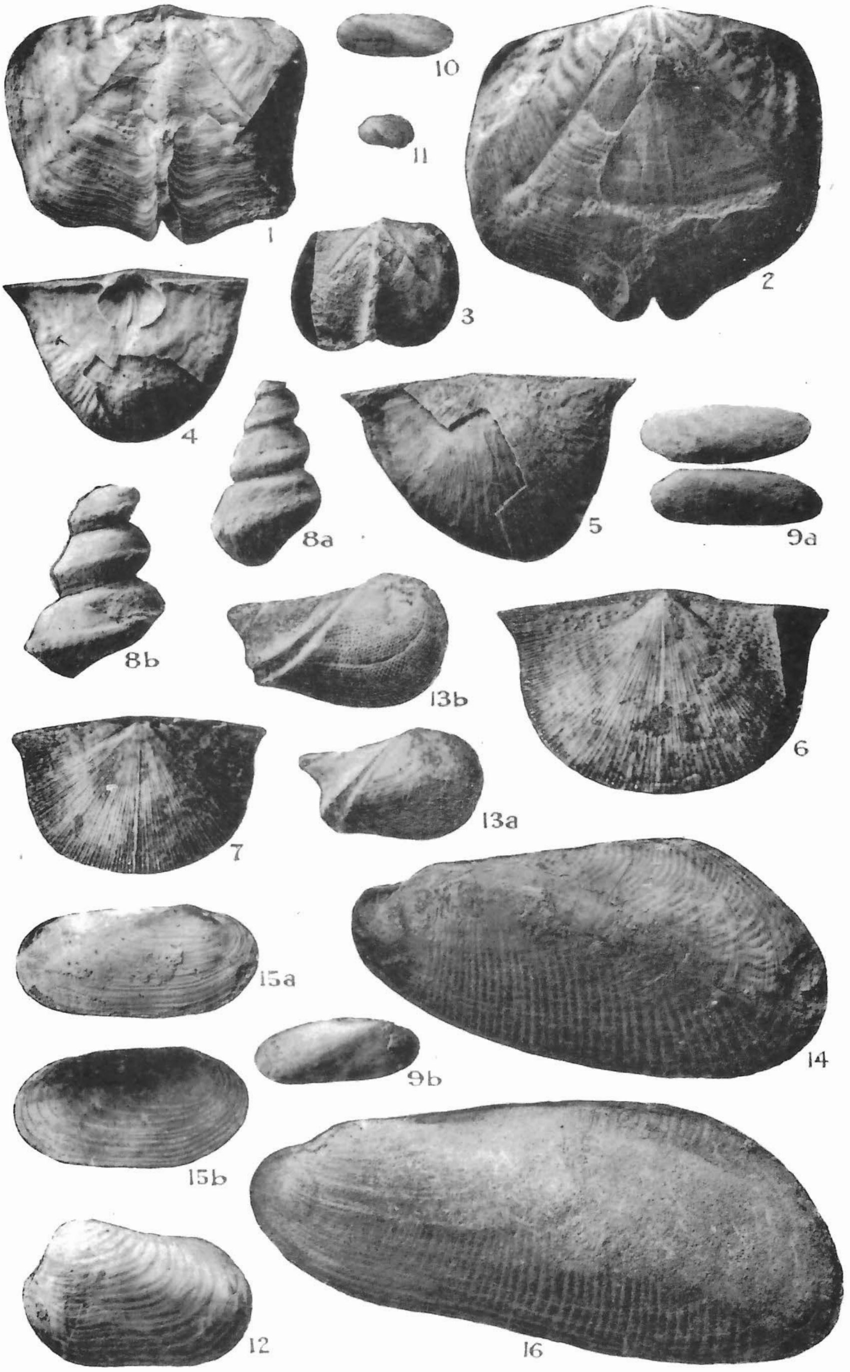


Plate XXXI

Figure 1. *Modiodesma modiolare* (Hall). Left valve. Half a mile east of Worthville, New York, along a creek north of the pike. Pulaski member, Lorraine. (Page 191.)

Figure 2. *Rafinesquina nasuta* Conrad. *a*, *b*, casts of interiors of pedicle valves. From a ferruginous boulder containing *Cryptolithus*, a short distance west of the railway bridge, a mile east of Pulaski, New York. Originally a calcareous layer in the Pulaski member of the Lorraine. (Page 115.)

Figure 3. *Archinacella pulaskiensis* Foerste. *a*, *b*, two views of a specimen from a mile east of Pulaski, New York, west of the railway bridge crossing the river. Pulaski member, Lorraine. (Page 203.)

Figure 4. *Colpomya faba pusilla* Foerste. Two left valves, from the *Cryptolithus* layer in the Pulaski shale, west of the railway bridge, one mile east of Pulaski, New York. (Page 172.)

Figure 5. *Orthodesma nasutum* (Conrad). *a*, *b*, two right valves. Two and a half miles east of Worthville, New York. Upper part of Pulaski member, Lorraine. (Page 195.)

Figure 6. *Orthodesma pulaskiense* Foerste. Right valve. Immediately below the railway bridge, one mile east of Pulaski, New York. Pulaski member, Lorraine. (Page 194.)

Figure 7. *Cymatonota pholadis* (Conrad). Left valve. Near the head of the gulf west of Turin, New York, along the road leading southwest up the hill toward the schoolhouse. Pulaski member, Lorraine. (Page 175.)

Figure 8. *Ctenodonta lorrainensis* Foerste. Cast of interior of right valve. Half-way between Lorraine and Worthville, New York. Lorraine. (Page 137.)

Figure 9. *Ctenodonta borealis* Foerste. Cast of interior of right valve. Half-way between Lorraine and Worthville, New York. Lorraine. (Page 137.)

Figure 10. *Glyptorthis crispata* (Emmons). Brachial valve. Half-way between Lorraine and Worthville, New York. Lorraine. (Page 111.)

Figure 11. *Orthodesma* sp. At the crossroads one mile south of Barnes Corners, New York. *See* under *Orthodesma pulaskiensis*. Lorraine. (Page 195.)

Figure 12. *Pterinea* (*Caritodens*) *demissa* Conrad. Young left valve. Chambly village, Quebec. No. 8433. From the *Proetus* zone, Lorraine. (Page 161.)

Figure 13. *Byssonychia radiata* (Hall). *a*, right valve. *b*, *c*, left valves. Successively with 55, 47, and 48 radiating plications. *c*, is the original of Plate 80, figure 4 *a*, of Pal. New York, 1, 1847, and is selected as the type of the species. Pulaski, New York. Pulaski member, Lorraine. (Page 164.)

Figure 14. *Lingula* sp. Valve belonging to the *Lingula procteri* group. In the *Cryptolithus* layer, a short distance west of the railway bridge, one mile east of Pulaski, New York. Pulaski member, Lorraine. (Page 107.)

Figure 15. *Ischyrodonta unionoides* Meek. *a*, right valve. *b*, left valve. Bennett bridge, one mile down stream from Salmon River falls, New York. Upper part of Pulaski member, Lorraine. (Page 146.)

Plate No. XXXI

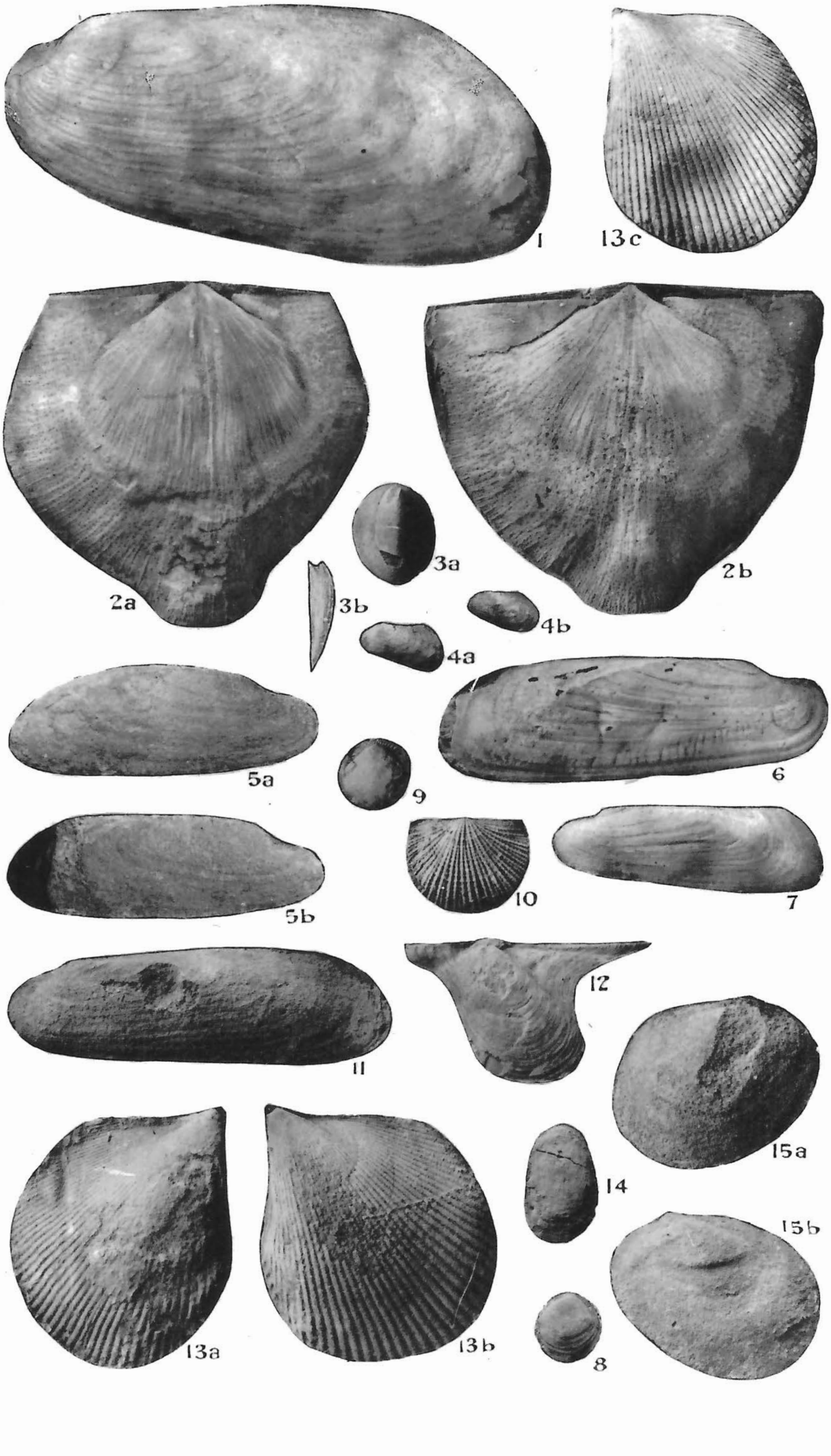


PLATE XXXII

FIGURES 1-3. *Modiodesma modiolare* (Conrad). 1. Specimen showing the two valves lying opened in a fine-grained, shaly sandstone. Shell itself wanting, but the specimen gives a composite idea of both external and internal characters. Concentric ribs and finer growth lines, originally only on the exterior surface, but the anterior muscular scar, which is obscurely indicated, and the slits along the hinge-margin were made by features on the inner side of the shell. (For sharp casts of the interior, *see* Plate XXXIII.)

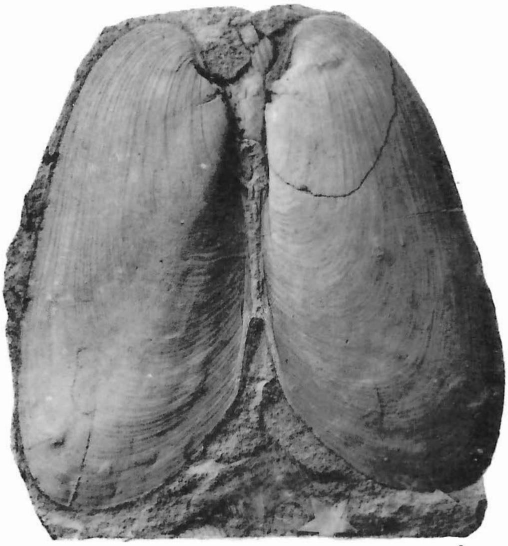
This is the original type of Conrad's *Pterinea modiolaris*, and is now made the genotype of *Modiodesma*. Lorraine. Near Rome, New York. In the New York State Museum at Albany. (Page 191.)

2. Nearly complete right valve of the rather long variety of this species. Lorraine group, just below the railway bridge at Pulaski, New York. U.S. National Museum. (Page 191.)

3. Anterior end and hinge of preceding (magnification : X 2), specimen so tilted as to give a more direct view of the slit made by the submarginal internal rib that made the channel in which the inner ligament was lodged. (Page 191.)

FIGURES 4-5. *Modiodesma modiolare angustifrons* (Conrad). 4. Original type of Conrad's *Cypricardites angustifrons;* here referred to *M. modiolaris* as a distinguishable variety. As will be observed when compared with figures 1 and 2, this variety differs from the more typical forms of the species in the sharply angulated, instead of rounded, anterior extremity. The specimen is more a cast of the interior than of the exterior, hence gives a very imperfect idea of the surface markings. Lorraine. Near Rome, New York. New York State Museum, Albany, New York. (Page 189.)

5. Another specimen of this variety, preserved as a cast of the exterior and, therefore, giving a better conception of the concentric ribbing of the anterior half of the surface. Drifted Lorraine slabs, near Trenton Falls, New York. U.S. National Museum.



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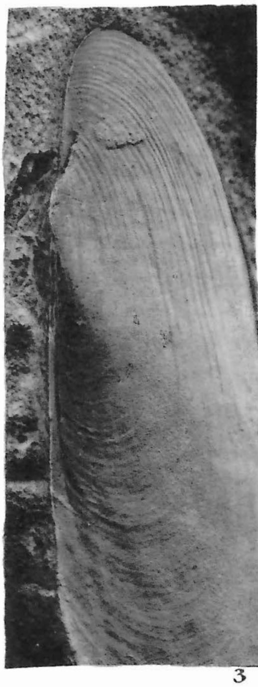

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2

4

5

PLATE XXXIII

FIGURES 1-2. *Modiodesma scaphan*. sp. Ulrich. 1. Right side. 2. dorsal view of the holotype. This species is distinguished by its elongate form, relatively well-developed umbonal ridge, rather strong concentric undulations of the median third of the surface of both the exterior and interior, and the broadly rounded, rather than obliquely truncated posterior end. Upper part of Fairview limestone, Cincinnati, Ohio. U.S. National Museum. The species occurs also in the Lorraine of New York. (Page 189.)

FIGURES 3-6. *Modiodesma modiolare* (Conrad). 3. Left side of a sharply preserved cast of the interior showing muscular scars, pallial line, and other markings of the interior that are seldom clearly visible on specimens of this species. (Page 191.)

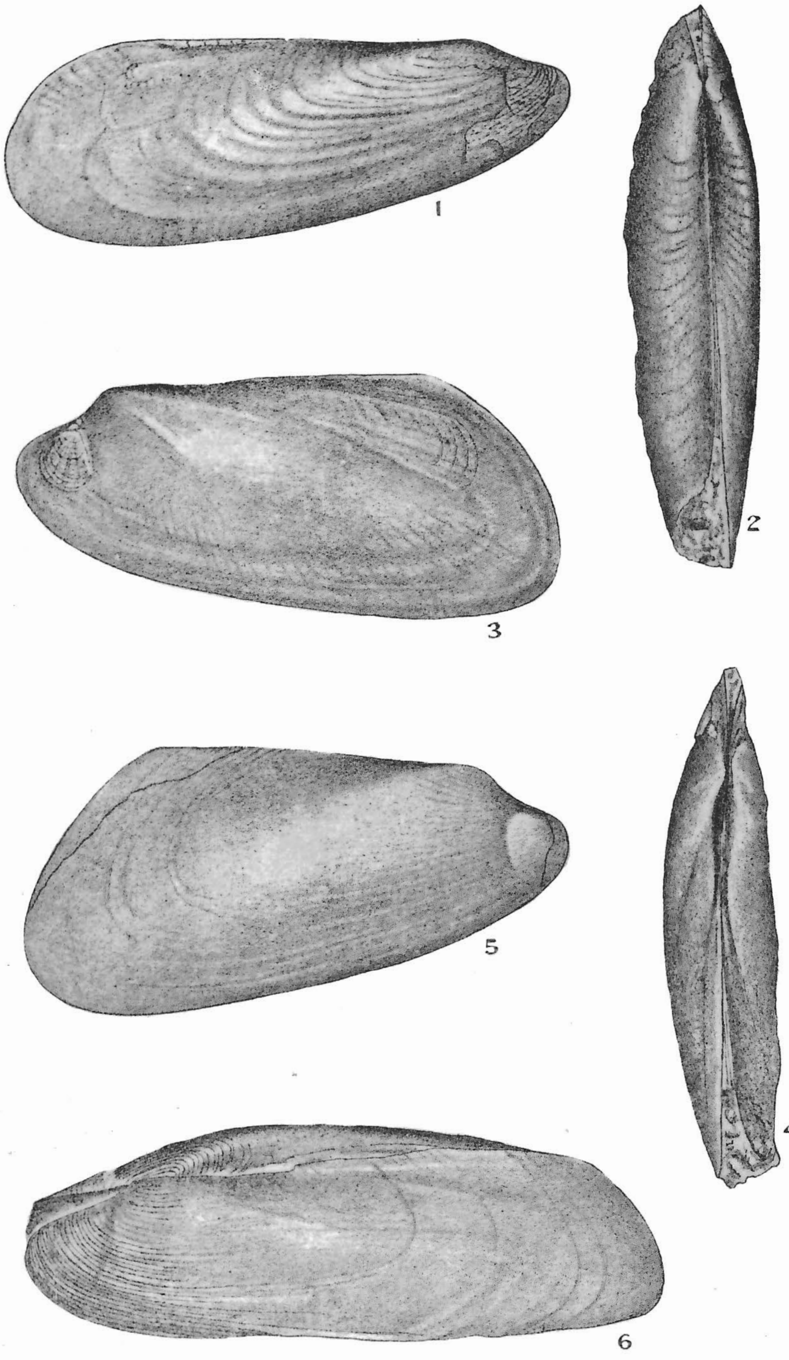
4. Dorsal view of same, the valves partly open, the right broken so as to give an irregular profile, the left only showing the normal profile. Remains of both the internal and external ligaments preserved. The open valves partly embrace the holotype of *Modiodesma scapha.* (Page 191.)

5. A specimen with outline slightly restored. It is to be described as a cast of the interior rather than of the exterior and illustrates one of the more common preservation facies. (Page 191.)

6. Left side of a crushed shell preserved in soft calcareous shale, mainly as a cast of the exterior. (Page 191.)

Upper part of the Fairview limestone, Cincinnati, Ohio. U.S. National Museum.

Plate No. XXXIII



1 2 3 4 5 6

Plate XXXIV

Figure 1. *Archinacella richmondensis* Ulrich. *a*, dorsal view; *b*, profile view. Richmond, Indiana. Whitewater member, Richmond. Geol. Surv., Minnesota, 3, pt. 2, pl. 61, figs. 6, 7. (Page 201.)

Figure 2. *Cyrtolites carinatus* Miller. *a*, lateral view; *b*, *c*, dorsal views from different directions. Magnification: X 2. Newport, Kentucky. Southgate member, Eden. Geol. Minnesota, 3, pt. 2, pl. 62, figs. 50-52. (Page 205.)

Figure 3. *Cyrtolites ornatus* Conrad. Lateral view. Cincinnati, Ohio. Maysville. Geol. Minnesota, 3, pt. 2, pl. 62, fig. 27. (Page 203.)

Figure 4. *Cyrtolites parvus* Ulrich. *a*, lateral view; *b*, dorsal view. Magnification: X 2. Covington, Kentucky. Cynthiana. Geol. Minnesota, 3, pt. 2, pl. 62, figs. 45, 47. (Page 205.)

Figure 5. *Cyrtolites subplanus* Ulrich. Lateral view. Nashville, Tennessee. Catheys member, Trenton. Geol. Minnesota, 3, pt. 2, pl. 62, fig. 40. (Page 204.)

Figure 6. *Sinuites cancellatus* (Hall). *a*, lateral view; *b*, dorsal view. Chatfield, Minnesota. Decorah member, Black River. Geol. Minnesota, 3, pt. 2, pl. 63, figs. 5, 6. (Page 205.)

Figure 7. *Oxydiscus subacutus* Ulrich. *a*, lateral view; *b*, view of aperture and dorsum. Danville, Kentucky. Flanagan member, Trenton. Geol. Minnesota 3, pt. 2, pl. 62, fig. 63; pl. 82, fig. 24. Magnification: *a*, slight; *b*, X 2. (Page 206.)

Figure 8. *Salpingostoma richmondensis* Ulrich. Dorsal view, showing open dorsal slit. Richmond, Indiana. Whitewater member, Richmond. Geol. Minnesota, 3, pt. 2, pl. 67, fig. 39. (Page 206.)

Figure 9. *Bellerophon mohri* Miller. View of aperture. Richmond, Indiana. Whitewater member, Richmond. Geol. Minnesota, 3, pt. 2, pl. 64, fig. 45. (Page 208.)

Figure 10. *Liospira micula* (Hall). *a*, top view; *b*, lateral view; *c*, basal view, showing umbilicus closed by reflexed callosity of inner lip. Covington, Kentucky. Eden. Geol. Surv. Minnesota, 3, pt. 2, pl. 68, figs. 24, 25, 26. (Page 208.)

Figure 11. *Eotomaria canalifera* Ulrich. Lateral view. Murfreesboro, Tennessee. Murfreesboro member, Stones River. Geol. Minnesota, 3, pt. 2, pl. 69, fig. 10. (Page 210.)

Figure 12. *Clathrospira subconica* (Hall). Lateral view. Minneapolis, Minnesota. Platteville member, Black River. Geol. Minnesota, 3, pt. 2, pl. 69, fig. 50. (Page 210.)

Figure 13. *Lophospira obliqua* Ulrich and Scofield. Lateral view. Mercer county, Kentucky. Tyrone member, Black River. Geol. Minnesota, 3, pt. 2, pl. 72, fig. 8. (Page 212.)

Figure 14. *Lophospira elevata* Ulrich and Scofield. Lateral view, showing aperture. Burgin, Kentucky. Flanagan member, Trenton. Geol. Minnesota, 3, pt. 2, pl. 73, fig. 11. (Page 212.)

Figure 15. *Lophospira tropidophora* (Meek). Lateral view. Newport, Kentucky. Maysville. Geol. Minnesota, 3, pt. 2, pl. 72, fig. 36. (Page 212.)

Figure 16. *Lophospira bowdeni* (Safford). Lateral view. Boyle county, Kentucky. Richmond. Geol. Minnesota, 3, pt. 2, pl. 72, fig. 40. (Page 214.)

Figure 17. *Lophospira sumnerensis* (Safford). Lateral view. Sumner county, Tennessee. Catheys member, Trenton. Geol. Minnesota, 3, pt. 2, pl. 73, fig. 19. (Page 213.)

Figure 18. *Lophospira notabilis* Ulrich. Lateral view. Maury county, Tennessee. Lowville member, Black River. Geol. Minnesota, 3, pt. 2, pl. 72, fig. 33. (Page 215.)

Figure 19. *Hormotoma gracilis sublaxa* Ulrich and Scofield. Lateral view. Lincoln county, Missouri. Auburn member, Black River. Geol. Minnesota, 3, pt. 2, pl. 70, fig. 23. (Page 216.)

Figure 20. *Hormotoma gracilis angustata* (Hall). Lateral view, showing aperture. Newport, Kentucky. Eden. Geol. Minnesota, 3, pt. 2, pl. 70, fig. 34. (Page 215.)

Figure 21. *Helicotoma planulata* Salter. Lateral view. Paquette rapids, Black River. Geol. Minnesota, 3, pt. 2, pl. 74, fig. 16. (Page 216.)

Figure 22. *Helicotoma planulatoides* Ulrich. Top view. Mercer county, Kentucky. Lowville member, Black River. Geol. Minnesota, 3, pt. 2, pl. 74, fig. 28. (Page 216.)

Figure 23. *Helicotoma brocki* Foerste. *a*, lateral view; *b*, top view. Kagawong falls. Waynesville member, Richmond. Bull. Denison Univ., 17, 1912, pl. 10, fig. 11; pl. 12, fig. 3. (Page 216.)

Figure 24. *Cyclonema bilix conicum* (Miller). Lateral view. Versailles, Indiana. Richmond. Geol. Minnesota, 3, pt. 2, pl. 78, fig. 39. (Page 217.)

Figure 25. *Holopea insignis* Ulrich and Scofield. Lateral view. Cannon falls, Minnesota. Platteville member, Black River. Geol. Minnesota, 3, pt. 2, pl. 79, fig. 3. (Page 217.)

Plate No. XXXIV

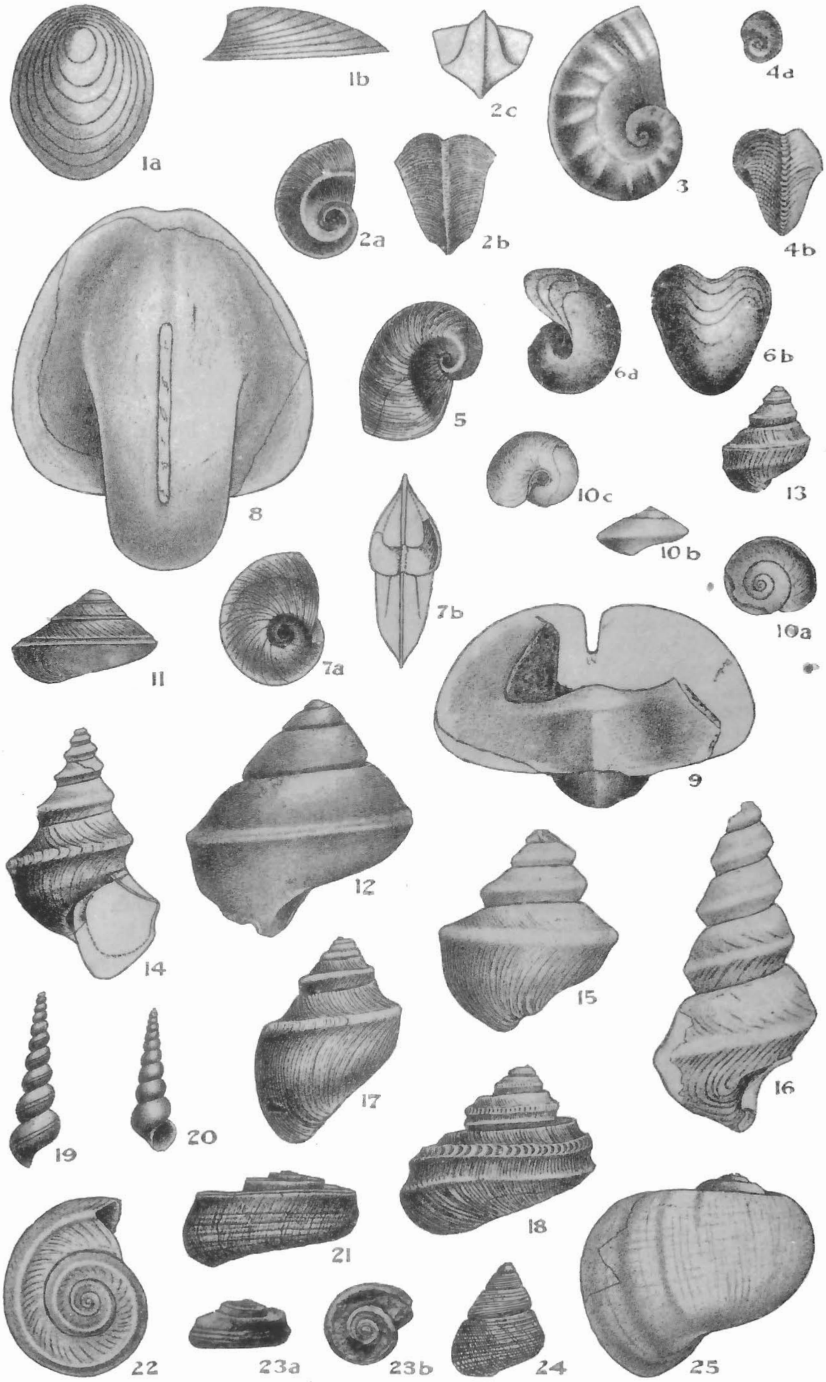


PLATE XXXV

FIGURE 1. *Vallatotheca manitoulinensis* Foerste. *a,* lateral view. *b,* dorsal view. *c,* lateral view showing radiating striations between the projecting margins of the concentric lamellæ. *c,* Magnification: X 2. No. 8448, Clay cliffs. Richmond. (Page 203.)

FIGURE 2. *Archinacella kagawongensis* Foerste. *a, b,* dorsal and lateral views of same specimen, with anterior margin restored. *c, d,* interior and lateral views of another specimen. No. 8461. Two miles southwest of Kagawong. Richmond. (Page 202)

FIGURE 3. *Archinacella lævis* sp. nov. *a, b,* dorsal and lateral views of the same specimen. *c, d,* dorsal and lateral views of another specimen. No. 8460. Snake island. Richmond. (Page 202.)

FIGURE 4. *Bellerophon parksi* sp. nov. *a,* dorsal view showing transverse striæ and dorsal ridge; *b,* lateral view of the same; *c,* view of aperture showing callosity along inner margin. *d,* anterior view of another specimen, showing dorsal ridge. *e,* lateral view of a third specimen showing profile of callosity along inner margin of aperture; *f,* dorsal view of same. Lateral and outer margin restored in all figures, especially in *d, e, f.* No. 8490, Clay cliffs, Richmond. (Page 208.)

FIGURE 5. *Cyrtolites carinatus* Miller. *a,* lateral view, showing umbilicus; *b,* dorsal view of another specimen. Both figures. Magnification: X 1·3. No. 8468, Tamarack point, 7 miles west of Little Current. Sheguiandah formation. (Page 205.)

FIGURE 6. *Salpingostoma* (?) *lata* sp. nov. *a,* specimen with strongly thickened border of aperture. *b,* fragment of a second specimen, with narrow, deep umbilicus, also showing part of the very thick lateral border of the aperture (on the left), and the area of attachment of the opposite lateral border to the preceding whorl of the shell. *c,* dorsal view of a third fragment, showing dorsal ridge, transverse striæ, and short striæ perpendicular to the latter, as in *Bucania* and *Salpingostoma.* No specimen found is sufficiently well preserved to demonstrate the presence or absence of a dorsal slit. No. 8492, from 2 miles southwest of Wekwemikong. Richmond. (Page 207.)

Plate No. XXXV

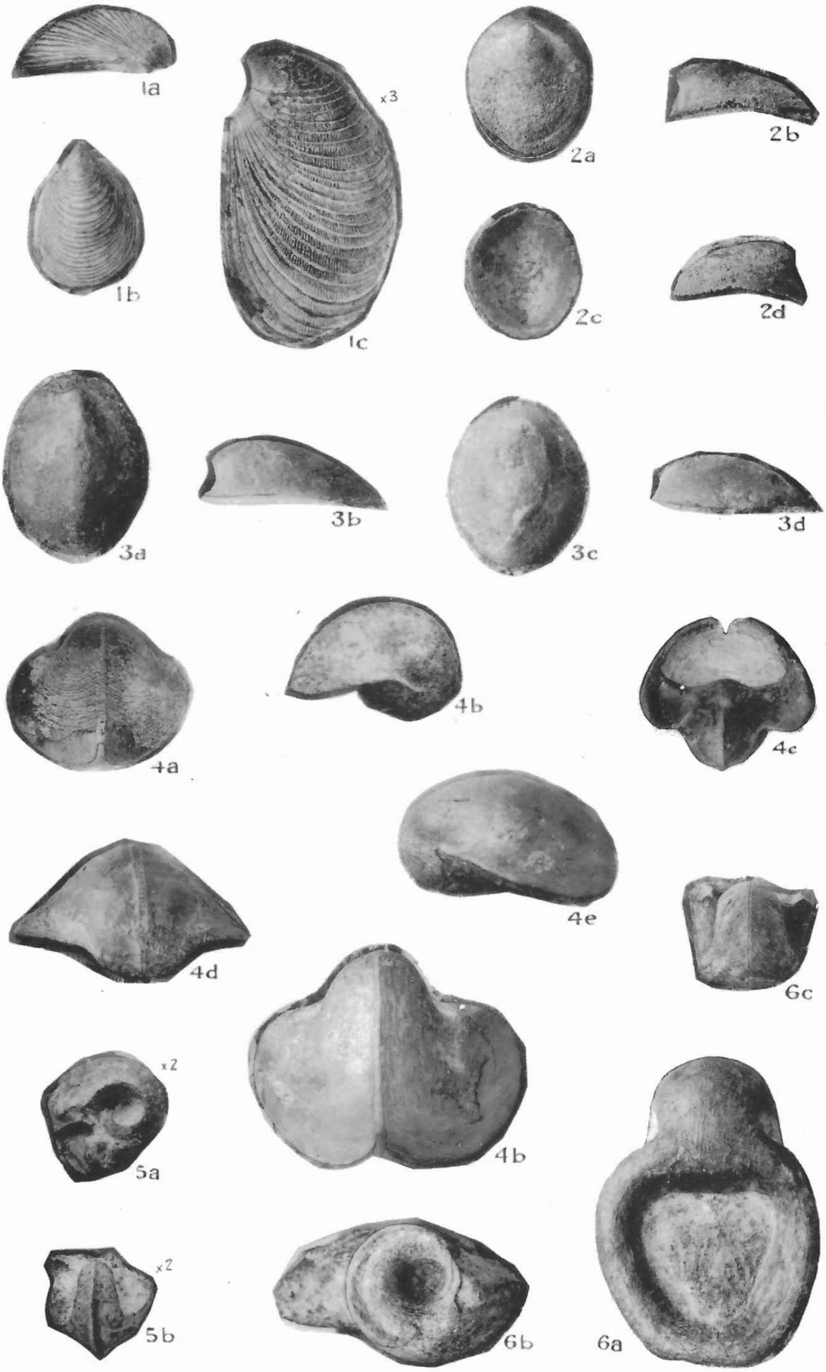


Plate XXXVI

Figure 1. *Liospira helena* (Billings). *a*, apertural view. *b*, umbilical view of same. *c*, apical view; exterior margin of aperture restored. No. 2122, one of the types. Clay cliffs. Richmond. Collector, R. Bell. (Page 209.)

Figure 2. *Liospira* cf. *micula* (Hall). *a*, apical view. *b*, view showing closed umbilicus; with margin of aperture restored in *a*. Magnification: X $1\frac{1}{2}$. No. 8464. Snake island. Richmond. (Page 208.)

Figure 3. *Eotomaria remotistriata* sp. nov. *a*, oblique view of strongly crushed specimen. *b*, apical view. Magnification: X 2. *a*, No. 8457, Vars. *b*, No. 8456, in Chambly Canton, below the dam. *Proetus* zone, Lorraine. (Page 210.)

Figure 4. *Clathrospira subconica* (Hall). Lateral views. *a*, No. 8459, Clay cliffs. Richmond. *b*, No. 8458, Nicolet river. Apparently from the *Pholadomorpha* zone, Lorraine. (Page 210.)

Figure 5. *Lophospira manitoulinensis* sp. nov. *a*, *b*, lateral views. *c*, *d*, apertural views, with only the inner margin of the aperture preserved. No. 8501, Clay cliffs. Richmond. (Page 213.)

Figure 6. *Holopea nicollettensis* sp. nov. *a*, lateral view; *b*, apical view. *c*, apertural view; with exterior margin of aperture restored. No. 8454, from Nicolet river. Waynesville member, Richmond. (Page 217.)

Plate No. XXXVI

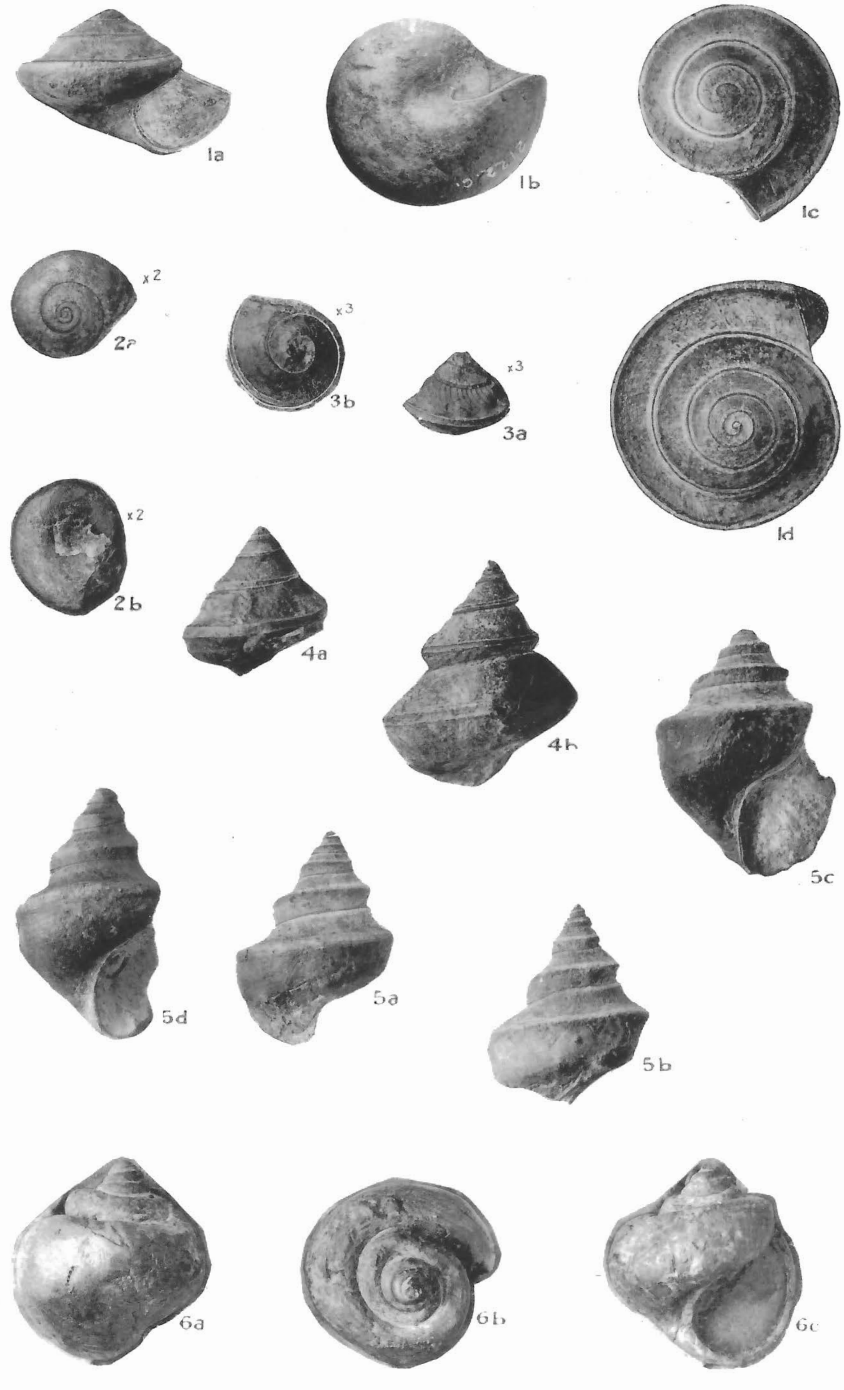


Plate XXXVII

Figure 1. *Lophospira kindlei* sp. nov. *a*, lateral view; *b*, same. Magnification: X 2. *c*, apertural view of same. *d*, apertural view of another specimen. Only the inner margin of the aperture is preserved in these specimens. No. 8505, Clay cliffs. Richmond. (Page 215.)

Figure 2. *Cyclonema bilix conicum* Miller. *a, b*, lateral views. Magnification: X 1½. No. 8493, Clay cliffs. Richmond. (Page 217.)

Figure 3. *Lophospira belli* sp. nov. *a*, lateral view. *b*, same. Magnification: X 2. *c*, another specimen. No. 8504, Clay cliffs. Richmond. (Page 212.)

Figure 4. *Lophospira latacarinata* sp. nov. *a*, lateral view showing inner margin of aperture. *b*, another specimen, showing longer spire. *c*, lower part of a larger specimen, showing inner margin of aperture. Magnification: X 1½. No. 8469, 2 miles southwest of Kagawong. Richmond. (Page 212.)

Plate No. XXXVII

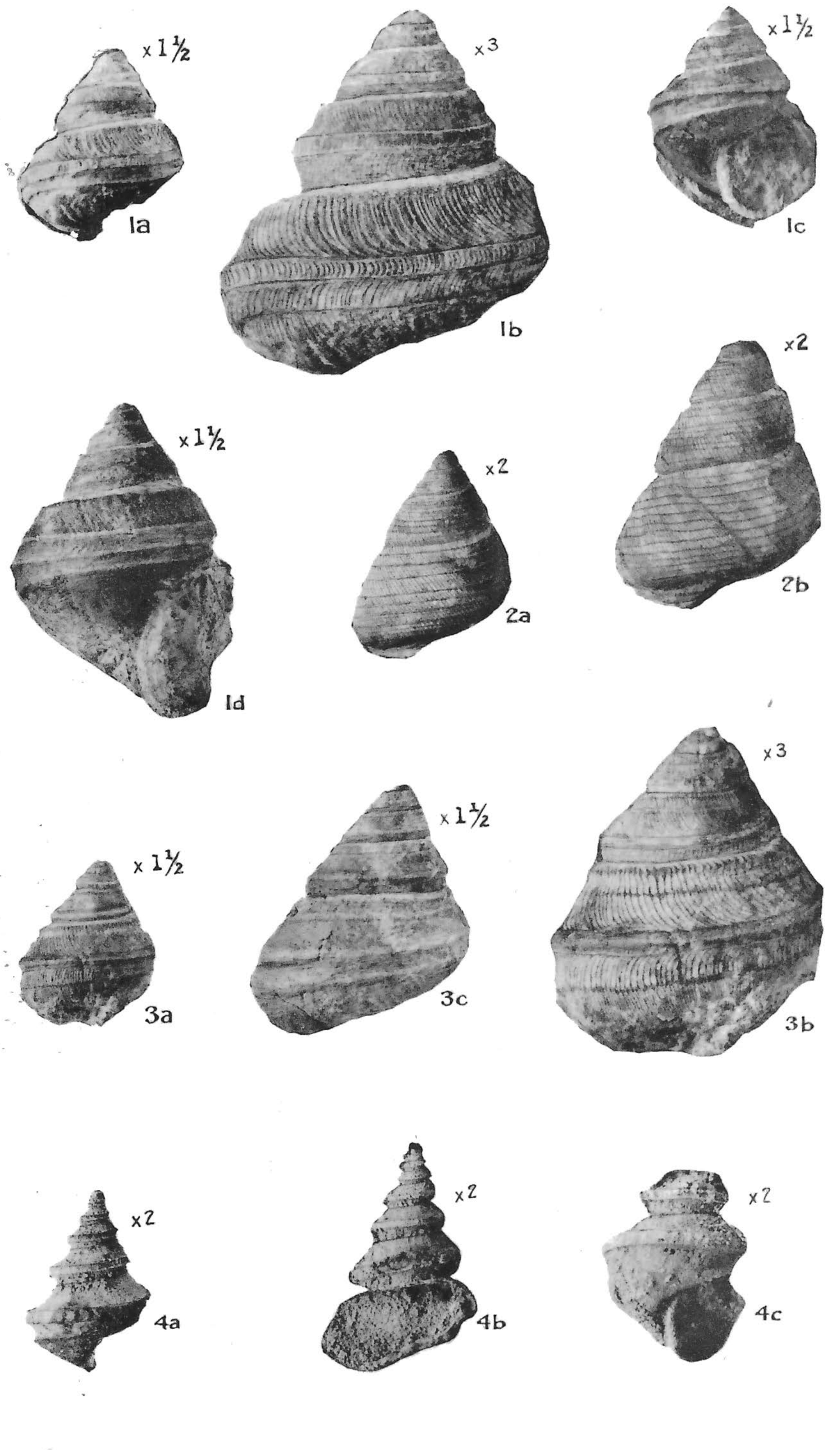


Plate XXXVIII

Figure 1. *Cyrtodonta ponderosa* Billings. *a*, type specimen, after cleaning, to show the considerable height of the ligamental areas along the hinge-line. The specimen is obliquely compressed, pushing the anterior part of the right valve forward beyond that of the left valve. *b*, left valve, with a small part of the upper anterior portion of the right valve visible also. No. 2081, Clay cliffs. Richmond. *See also* Plate XVIII, figure 1 *a*, *b*, *c*. (Page 142).

Figure 2. *Rhytimya granulosa* Wilson. Right valve of type specimen. Magnification: X 1½. From Vars, 12 miles east of Ottawa, between lots 20 and 21, immediately west of the intersection of the roads between concessions VII and VIII, nearly 2 miles west of the station at Vars. *Proetus* zone, Richmond. (Page 200).

Figure 3. *Ctenodonta lorrainensis* Foerste. Cast of interior of right valve. Magnification: X 3. Same specimen as Plate XXXI, figure 8 *a*. From half-way between Lorraine and Worthville, New York. Lorraine. (Page 137).

Figure 4. *Ctenodonta borealis* Foerste. Cast of interior of right valve. Magnification: X 3. Same specimen as Plate XXXI, figure 8 *a*. From half-way between Lorraine and Worthville, New York. Lorraine. (Page 137).

Figure 5. *Oxydiscus perstriatus* Foerste. *a*, lateral view. Magnification: X 5. Dorsal margin narrowly acute, as in typical *Oxydiscus*. *b*, transverse section of whorl, near aperture, to show the prominence of the keel and the depth of the involution. Magnification: X 2. Clay cliffs. Richmond. (Page 205).

Figure 6. *Billingsites newberryi* (Billings). Dorso-lateral view, showing the base of the living chamber and one of the dorsal saddles. No. 2312 *a*, English Head, Anticosti, English Head and Vaurial members, Richmond. (Page 222).

Figure 7. *Billingsites* cf. *newberryi* (Billings). *a*, lateral view, with dorsal side on right. *b*, dorso-lateral view, with dorsal side on left; same specimen. Both figures show the base of the living chamber and two of the strong dorsal saddles. No. 2178 *b*, *c*, English Head and Vaurial members, Anticosti island; Richmond. (Page 222).

Figure 8. *Maelonoceras* (*Beloitoceras*) *ligarius* (Billings). Cast of interior of phragmacone. North point, Drummond island. Richmond. No. 2175. (Page 229).

Figure 9. *Orthodesma nasutum* (Conrad). Left valve, injured along its upper margin, anterior to the beak, so that the outline here is incorrect. Original of Plate 81, figure 2, of the New York Palæontology, vol. 1, 1847; No. 9600-1, in the New York State Museum, at Albany, New York. Labelled as coming from Lorraine, Jefferson county, New York. (Page 195).

Plate No. XXXVIII

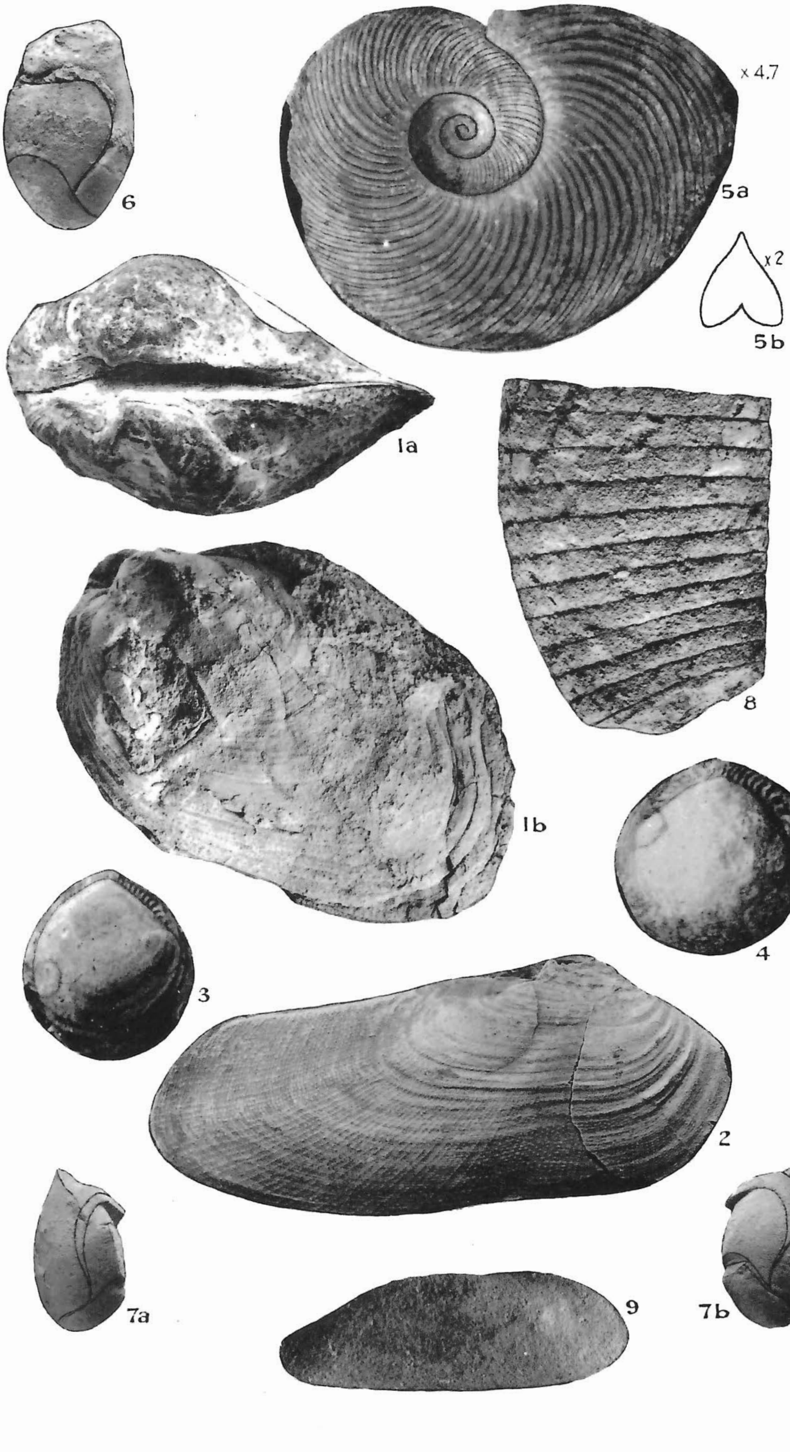


Plate XXXIX

Figure 1. *Spyroceras hammelli* (Foerste). *a*, lateral view. *b*, another specimen, cut so as to show two annulations of the siphuncle. An enlarged view of the striæ on *a* Plate XL, figure 3. *a*, No. 2167, *b*, No. 8537, both from Clay cliffs. Richmond. *a*, collector, R. Bell. (Page 222).

Figure 2. *Spyroceras parksi* sp. nov. Lateral view. An enlarged view of the striæ of the same specimen is presented on Plate XL, figure 4. No. 8538, Clay cliffs. Richmond. (Page 223).

Figure 3. *Spyroceras chambliense* sp. nov. Entire width of a specimen, crushed flat. Former width probably two-thirds as great. (*See* Plate XL, figure 1.) No. 8568, Chambly Canton. *Proetus* zone, Lorraine. (Page 222).

Figure 4. *Sactoceras manitoulinense* sp. nov. *a*, a smaller specimen, showing vertical bars of colour beneath the outer epidermis. *b*, another specimen, showing location of the septa. *c*, vertical section of a small fragment, showing annulations of the siphuncle. No. 8539, Clay cliffs. Richmond. (Page 224).

Figure 5. *Sactoceras westonense* sp. nov. Lateral view, showing vertical colour markings beneath the outer epidermis, narrower than in the preceding species. No. 2174, Weston, Ontario. An enlarged view of the surface striæ is presented on Plate XL, figure 2. Lorraine. Collector, J. B. Tyrrell. (Page 226).

Plate No. XXXIX

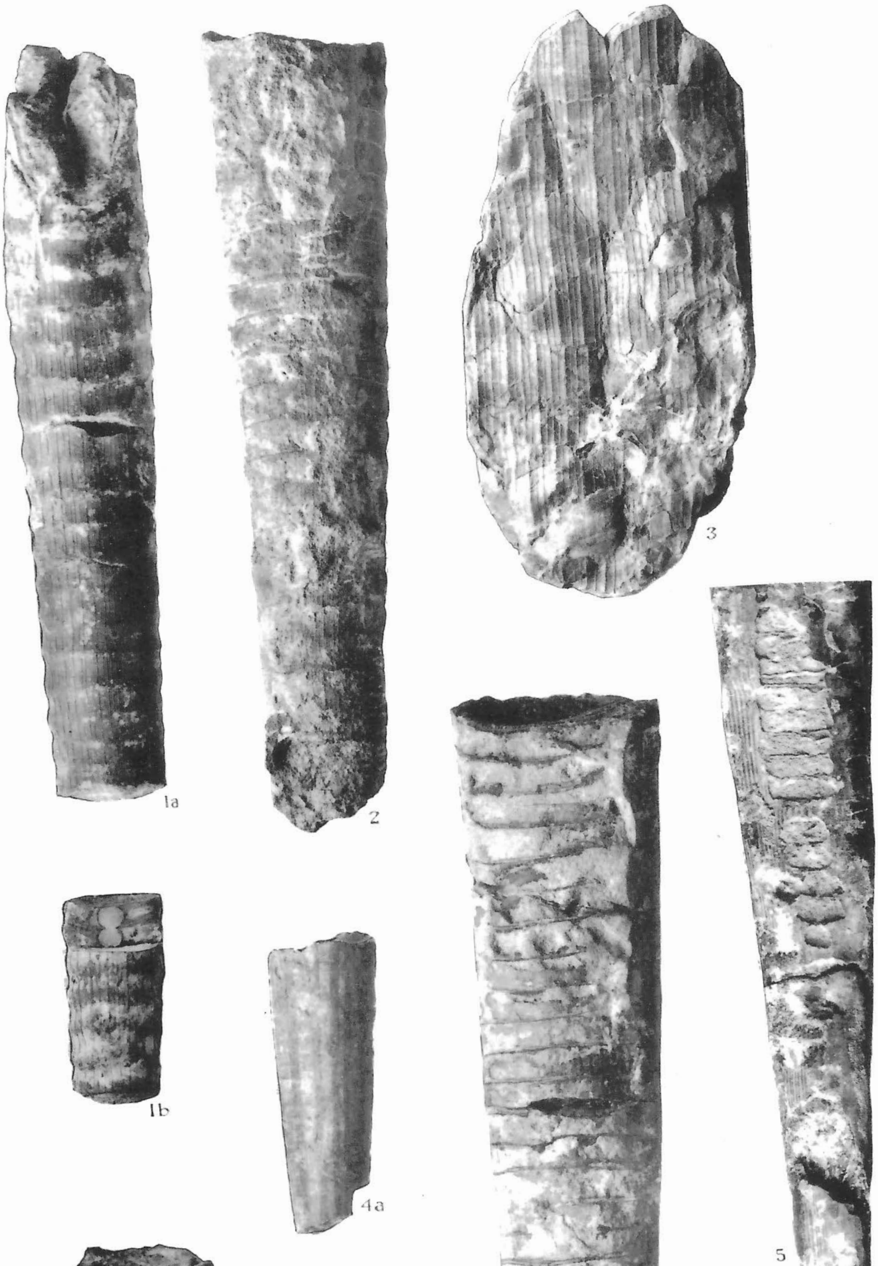


Plate XL

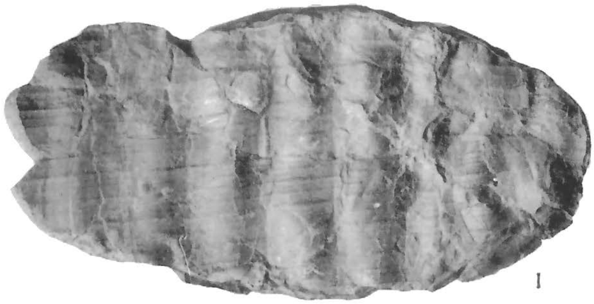
Figure 1. *Spyroceras chambliense* sp. nov. Another view of the specimen figured on Plate XXXIX, figure 3, illuminated so as to show the annulations. (Page 222).

Figure 2. *Sactoceras westonense* sp. nov. A small part of the surface of that half of the specimen which is on the side opposite to that presented on Plate V, figure 5, here is enlarged 9 diameters, to indicate the very fine vertical striæ. (Page 226).

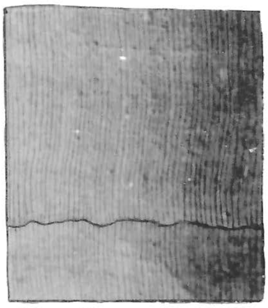
Figure 3. *Spyroceras hammelli* (Foerste). A part of Plate XXXIX, figure 1 *a*, to show the surface striæ. Magnification: X 3. (Page 222.)

Figure 4. *Spyroceras parksi* sp. nov. A part of Plate XXXIX, figure 2, to show the surface striæ. Magnification: X 3. (Page 223).

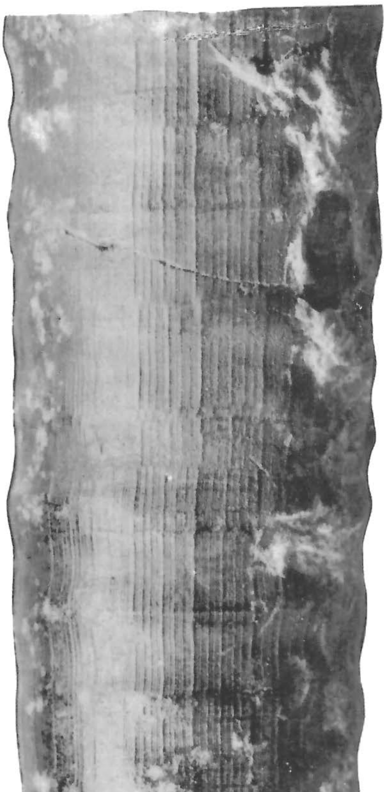
Plate No. XL



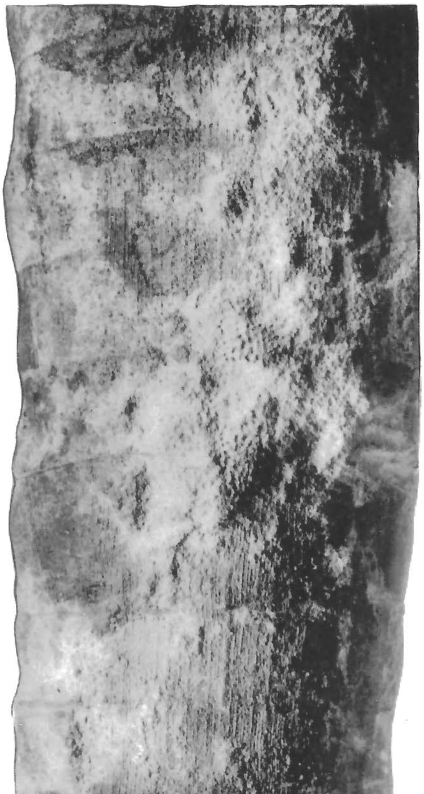
1



x9 2



x3 3



x3 4

Plate XLI

Figure 1. *Manitoulinoceras postumius* Billings. Vertical section of type specimen, encrusted by *Stromatocerium*, with the septa, annulations of the siphuncle, and surface of the conch outlined in ink. No. 2176, Clay cliffs. Richmond. Collector, R. Bell. (Page 232).

Figure 2. *Maelonoceras (Beloitoceras) ligarius* (Billings). Vertical section, showing position of septa and several of the annulations of the siphuncle; apparently a part of the type specimen. No. 2175, North point, Drummond island. Richmond. (Page 229).

Figure 3. *Zitteloceras hitzi* (Foerste). *a*, view of concave side, with several transverse striæ added to indicate the backward flexure of striæ along the median line of the convex side. *b*, lateral view of same specimen with convex side embedded in the rock matrix, but with outline of this side indicated. Two miles southwest of Kagawong. Richmond. (Page 233).

Figure 4. *Manitoulinoceras lysander* (Billings). *a, b,* lateral and concave sides of one of the types figured by Billings; the latter shows traces of vertical markings on the fragment of exfoliated shell remaining. *c, d, e,* convex, lateral, and concave sides of another unfigured specimen in the type series, showing surface markings. *f*, a part of the surface of another specimen cut away so as to show the moderately annulated siphuncle. Billings figured only the polished surface of this section. No. 2177, Clay cliffs. Richmond. (Page 230).

Figure 5. *Oncoceras pauper* sp. nov. *a*, concave side of curvature of lower part of shell. *b*, lateral view with concave side on right. No. 8542, Clay cliffs. Richmond. (Page 234).

Figure 6. *Sactoceras* (?) sp. Sides of specimen restored at top of figure; cut so as to expose several transverse septa. Siphuncle apparently very narrow, but rather irregular in form and may have been much broader and distinctly annulated, the narrow clay filling representing merely a deposit along the central line of the siphuncle. No. 8541, Clay cliffs. Richmond. (Page 226).

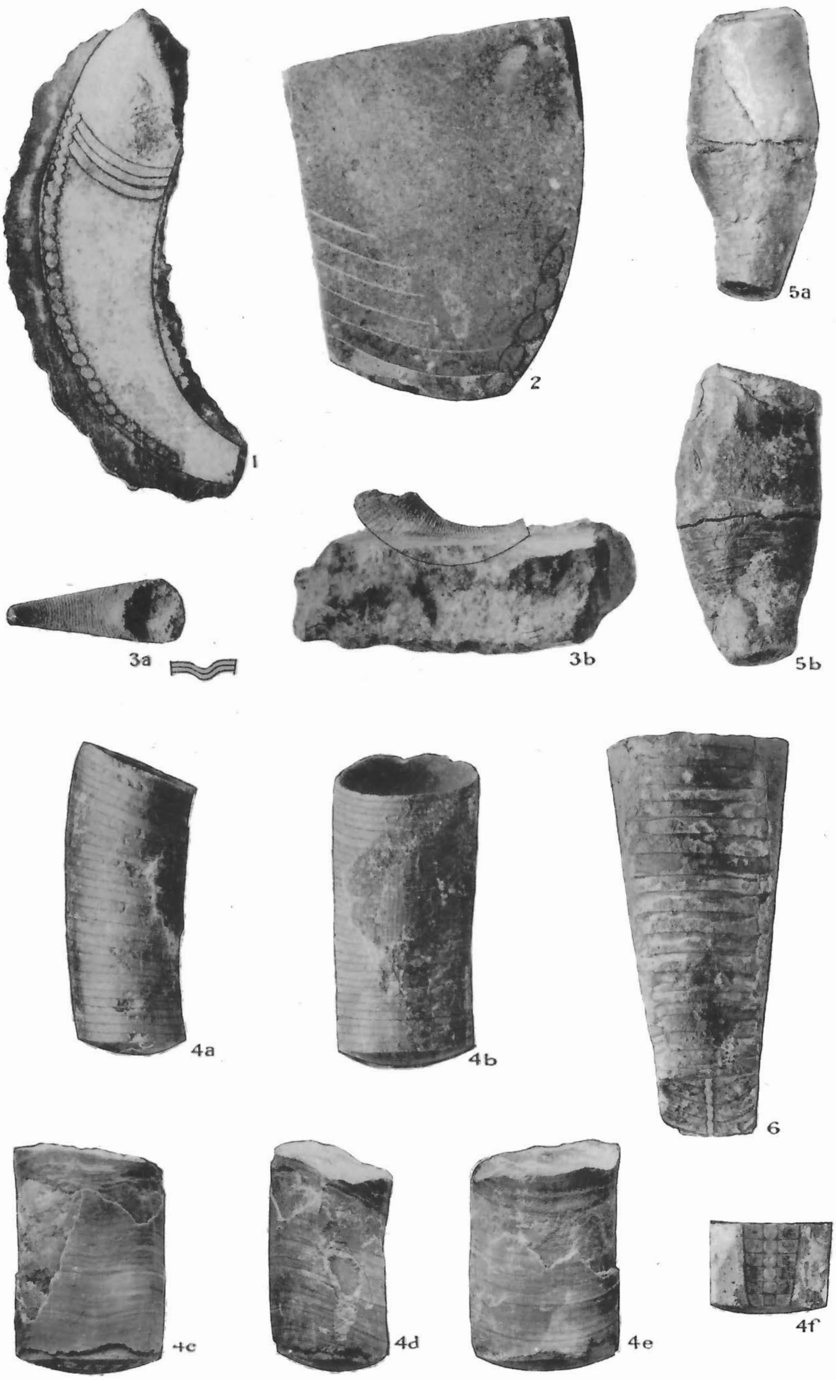

1
2
5a
3a
3b
5b
4a
4b
6
4c
4d
4e
4f

Plate XLII

Figure 1. *Billingsites manitoulinensis* sp. nov. *a, b, c, d,* views of convex, lateral, concave, and another lateral view of the conch, the second lateral view being on the side opposite the first. Sutures of the septa exposed more or less. Traces of the suture of the more elevated saddle-shaped septum seen in figures *b* and *c* are so obscure that they may not have been correctly interpreted; course of suture suggested chiefly by the character of the fracture of the shell as shown in figure *b*, and by the flexure of the wall of the shell for a short distance above this fracture. No. 8452, Clay cliffs. Richmond. (Page 221.)

Figure 2. *Kindleoceras reversatum* sp. nov. *a, b, c,* flattened, lateral, and convex sides of the same specimen, the last figure showing traces of the broad, low annulations of the siphuncle. No. 8582, Clay cliffs. Richmond. (Page 227.)

Figure 3. *Actinoceras* (?) *lambei* sp. nov. *a,* vertical section, showing rapidly expanding siphuncle. *b,* surface markings of same specimen, the latter being still attached to the rock matrix. No. 8545, Clay cliffs. Richmond. (Page 228.)

Plate No. XLII

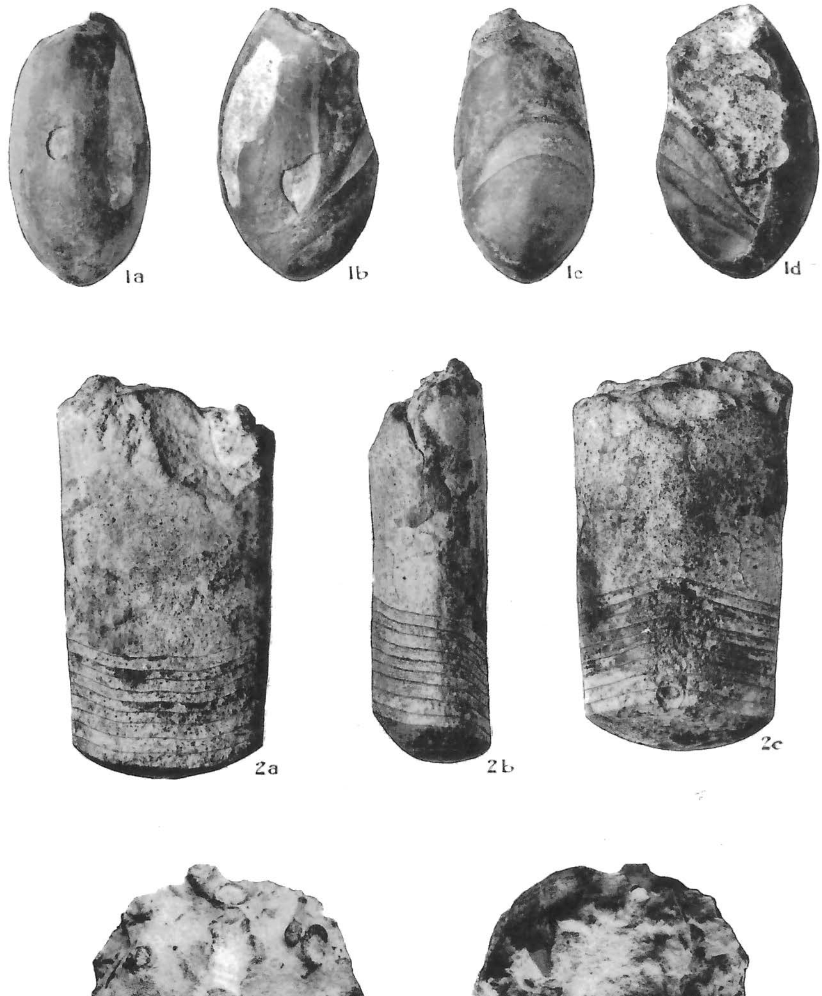


PLATE XLIII

FIGURES 1, 2. *Byssonychia hyacinthensis* sp. nov. 1, right valve. 2, left valve. The type, figure 2, shows the outline and radiating plications well. Figure 1 shows the plications along the anterior and umbonal parts of the shell well, but the posterior half of the valve is missing. St. Hyacinthe, at the northern end of the exposures below the dam. *Cryptolithus* zone, Lorraine. (Page 163.)

FIGURE 3. *Colpomya* (?) sp. Right side of shell. From the road side 2 miles southwest of Kagawong, on the road to Gore Bay, in silicified limestone belonging to the Kagawong member, Richmond. (Page 174.)

FIGURE 4. *Ortonella* (?) sp. Left side of shell, showing umbonal ridge, mesial depression, and distant concentric lines of growth. Clay cliffs. In the Meaford. (Page 150.)

FIGURE 5. *Lyrodesma poststriatum manitoulinensis* var. nov. Left valve, showing the striations on the post-umbonal slope. Magnification: X 1·7. Clay cliffs. Meaford member, Richmond. (Page 170.)

FIGURE 6. *Lyrodesma major* Ulrich. Cast of interior of left valve, showing the striations on post-umbonal slope. The specimen here figured shows an abruptly defined, nearly vertical depression immediately anterior to the beak, with one much shorter depression posterior to the beak, and another an equal distance toward the front. Magnification: X 1·7. There is no trace of these depressions in other specimens of the same species from the same locality and horizon, and their origin is unknown. Chambly Canton, below the dam crossing Richelieu river. *Proetus* zone. Lorraine. (Page 171.)

FIGURE 7. *Lyrodesma huguesensis* sp. nov. Right valve, with an abruptly-defined umbonal ridge, anterior to which the middle of the valve is only moderately convex. Striæ on the post-umbonal slope nearly equal in size. Magnification: X 1·7. On Yamaska river, about 1½ miles below St. Hugues. *Cryptolithus* zone, Lorraine. (Page 171.)

FIGURE 8. *Clidophorus tamarackensis* sp. nov. Right valve; cast of interior, showing the clavicular ridge in the form of a very narrow groove. Magnification: X 1·7. From Tamarack point, about 10 miles southwest of Little Current. Sheguiandah member. (Page 139.)

FIGURE 9. *Lyrodesma postriatum* (Conrad). Cast of interior of shell; right valve; possibly of variety *elongatum* Stewart; showing anterior and posterior muscle scars. Humber river. *Pholadomorpha* zone, Lorraine. (Page 169.)

FIGURE 10. *Lyrodesma postplanum* sp. nov. Right valve, with lower part of posterior margin missing; with no striations on the post-umbonal slope. Clay cliffs. Meaford member, Richmond. (Page 168.)

FIGURES 11-14. *Kindleoceras triangulare* gen. et sp. nov. 11, ventral side. 12, lateral side with the ventral side on the left; 13, dorsal side. 14, cross-section, showing location of siphuncle. Clay cliffs. Meaford member, Richmond. (Page 228.)

FIGURES 15-16. *Cryptolithus lorettensis* sp. nov. 15, cephalon, with the genal angles missing, and not exposing the posterior margin of the nuchal segments. Magnification: X 2. 16, the same. Magnification: X 5, to show the pitted surface. Falls of Lorette, northwest of Quebec city, Trenton. (Page 236.)

FIGURE 17. *Cryptolithus* sp. Cephalon, with genal spines missing. Magnification: X 2. Montmorency falls, near city of Quebec. No. 1773. Trenton. (Page 236.)

FIGURE 18. *Cryptolithus* cf. *recurvus* Ulrich. Cephalon, with genal angles missing; glabella badly crushed. Magnification: X 2. Nicolet River section. *Cryptolithus* zone. (Page 238.)

FIGURE 19. *Cryptolithus* cf. *bellulus* Ulrich. Cephalon, much distorted by pressure, with genal angles missing, but showing long, nuchal spine. Magnification: X 1·7. Yamaska river, 1½ miles below St. Hugues. *Cryptolithus* zone, associated with *Cryptolithus bellulus*. (Page 237.)

FIGURE 20. *Cryptolithus bellulus* Ulrich. Cephalons with nearly straight posterior margins, with genal spines not preserved. Magnification: X 1·7. Yamaska river, 1½ miles below St. Hugues. *Cryptolithus* zone. (Page 237.)

FIGURE 21. *Triarthrus huguesensis* sp. nov. Three cephalons, with rather narrow, triangular, fixed cheeks. Magnification: X 1·7. Yamaska river; 1½ miles below St. Hugnes. *Cryptolithus* zone. (Page 241.)

FIGURE 22. *Triarthrus becki* Green. Cranidium, showing quadratic fixed cheek. Trenton formation, near Albany, New York. From a specimen authenticated by Ruedemann. (Page 239.)

Plate No. XLIII

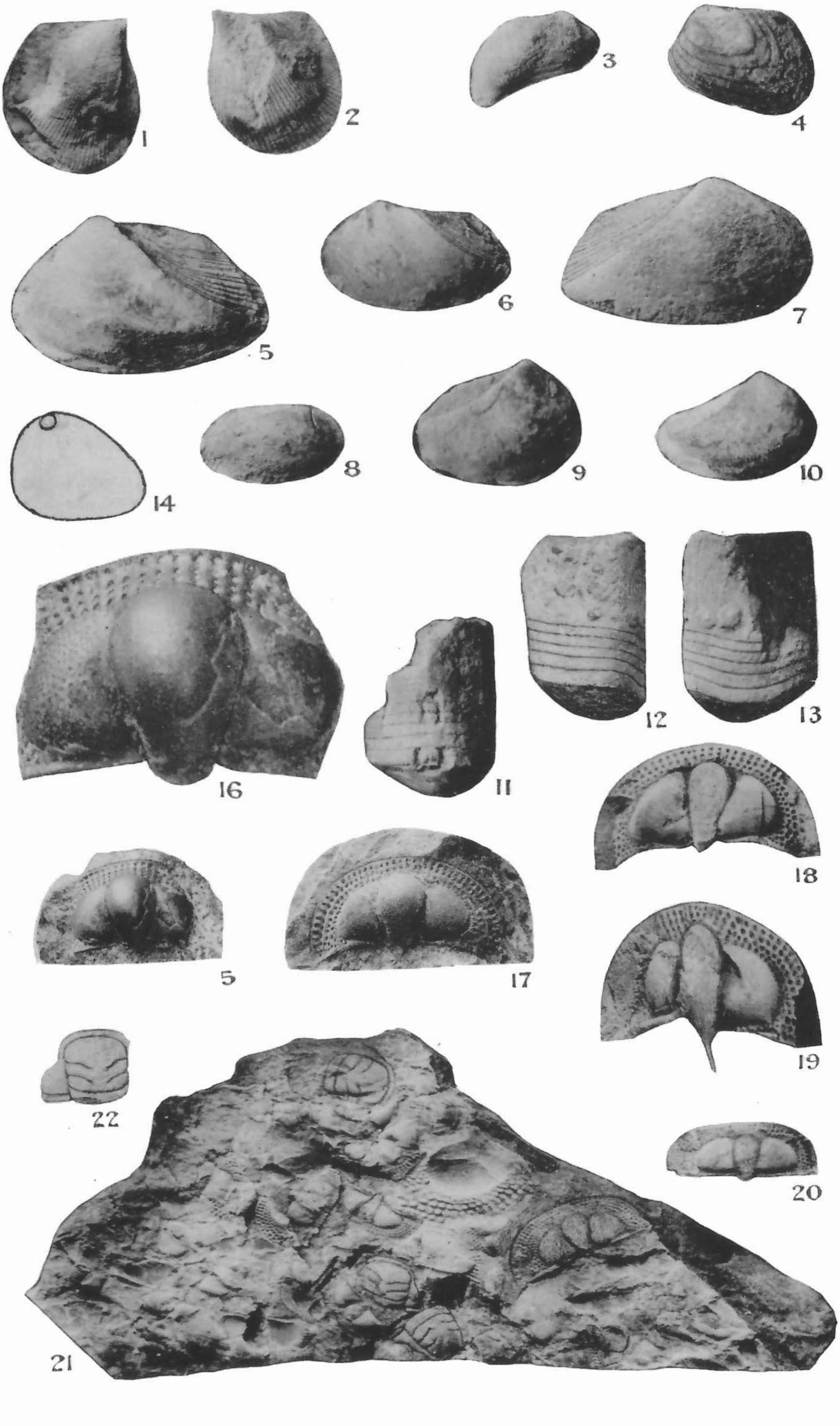


Plate XLIV

Figure 1. *Calymene granulosa* Foerste. *a*, entire individual. Magnification: X 1½. *b*, part of same, showing granulose surface. Magnification: X 6. From Cincinnati, Ohio. Eden. Bassler, Maryland Geol. Surv., Cambrian and Ordovician, 1919, p. 356, pl. 56, figs. 1, 2. (Page 246.)

Figure 2. *Calymene retrorsa* Foerste. Enrolled specimen, lateral view. Magnification: X 1½. From Silver creek, east of Dunlapsville, Indiana. Middle or Clarksville division, Waynesville member, Richmond. Bull. Denison Univ., 19, 1919, p. 76, pl. 18, fig. 2. *See also* fig. 15 on pl. 45. (Page 247.)

Figure 3. *Ceraurinus icarus* (Billings). *a*, cranidium; *b*, pygidium. No. 2186 *b*. (Page 249.)

Figure 4. *Homotelus stegops* (Green). From the Eden shale at Cincinnati, Ohio. Magnification: X 1·3. Same specimen as Plate 56, figure 4, of Cambrian and Ordovician, by Bassler, Geol. Surv., Maryland, 1919. (Page 243.)

Figure 5. *Isotelus megistos* Locke. Hypostoma, with missing part added in outline to give a conception of its size. Lower part of the McMillan division, Maysville, Morrow, Ohio. Same specimen as Plate 58, figure 11, of Cambrian and Ordovician, by Bassler. (Page 242.)

Figure 6. *Isotelus gigas* DeKay. From the Trenton limestone near Trenton Falls, New York. Magnification: X 1½. Same specimen as Plate 48, figure 25, of Cambrian and Ordovician, by Bassler. (Page 241.)

Figure 7. *Isotelus maximus* Locke. Pygidium, with left anterior corner missing. Manitowaning. Richmond. (Page 242.)

Plate No. XLIV

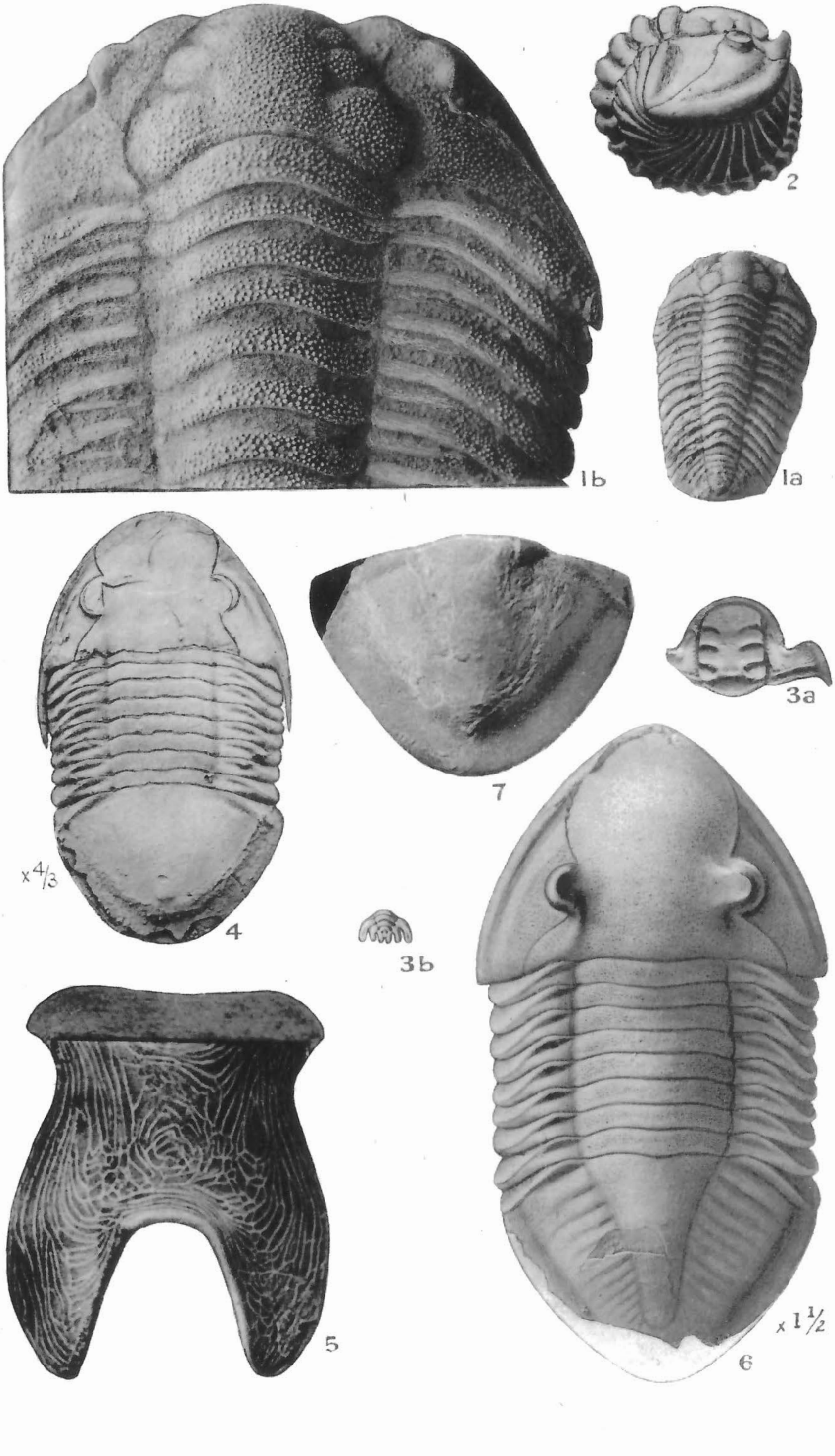


PLATE XLV

FIGURE 1. *Ceratopsis oculifera* (Hall). *a*, left valve. Magnification: X 20. *b*, profile view of same. Cincinnati, Ohio. Corryville member, Maysville. Geol. Surv., Ohio, Pal. 2, 1875, pl. 4, figs. 9, 10. (Page 251.)

FIGURE 2. *Ctenobolbina ciliata* (Emmons). Right valve. Magnification: X 25. Cincinnati, Ohio. Eden. Geol. Surv., Ohio, Pal. 2, 1875, pl. 4, fig. 8. (Page 252.)

FIGURE 3. *Laccoprimitia centralis* Ulrich. Left valve. Magnification: X 20. Covington, Kentucky. Cynthiana, Eden, and Maysville formations. Jour. Cincinnati Soc. Nat. Hist., 13, 1890, pl. 10, fig. 1. (Page 254.)

FIGURE 4. *Primitia lativia* Ulrich. Left valve. Magnification: X 18. Stony Mountain, Manitoba. Richmond. Geol. Surv., Can., Cont. Micro-Pal., pt. 2, 1889, pl. 9, fig. 8. (Page 254.)

FIGURE 5. *Leperditella glabra* Ulrich. Left valve. Magnification: X 20. Blanchester, Ohio. Whitewater member, Richmond. Jour. Cincinnati Soc. Nat Hist., 13, 1890, pl. 10, fig. 9 *a*. (Page 251.)

FIGURE 6. *Leperditia caecigena* Miller. *a*, right valve. Magnification: X 3. *b*, ventral view. Madison, Indiana. Saluda division, Whitewater member, Richmond. Jour. Cincinnati Soc. Nat. Hist., 13, 1891, pl. 11, figs. 6 *a*, *d*. (Page 250.)

FIGURE 7. *Jonesella crepidiformis* (Ulrich). Right valve. Magnification: X 18. Covington, Kentucky. Economy member, Eden. Geol. Minnesota, 3, pt. 2, 1894, p. 667, fig. 47 *a*. (Page 254.)

FIGURE 8. *Eurychilina striatomarginata* (Miller). Valve. Magnification: X 20. Three miles south of Osgood, Indiana. Saluda division, Whitewater member, Richmond. Cincinnati Quarterly Journal of Science, 1, 1874, p. 233, fig. 26. (Page 253.)

FIGURE 9. *Lepidocoleus jamesi* (Hall and Whitfield). *a*, *b*, detached plates. Magnification: X 12. Cincinnati, Ohio. Cynthiana, Eden, Maysville, and Richmond formations. Geol. Surv., Ohio, Pal. 2, 1875, pl. 4, figs. 1, 2. *c*, the genotype of *Lepidocoleus* regarded by its author, Faber, as identical in species with the form originally described as *Plumulites jamesi*. (Page 255.)

FIGURE 10. *Calymene* sp. Enrolled specimen. Don Valley brick-yard. Lorraine. Bull. Denison Univ., 19, 1919, pl. 18, fig. 1. (Page 247.)

FIGURE 11. *Calymene meeki* Foerste. *a*, enrolled specimen. *b*, same specimen viewed from the side. Magnification: X 1½. Dunlapsville, Indiana. Middle or Clarksville division, Waynesville member, Richmond. Bull. Denison Univ., 16, 1910, pl. 3, fig. 19; idem., 19, 1919, pl. 18, fig. 3. (Page 246.)

FIGURE 12. *Cryptolithus recurvus* Ulrich. *a*, nearly entire individual, with tips of genal spines missing; part of marginal rim of cephalon and of pygidium restored on left side of specimen. *b*, fragment showing genal spine. Posterior margin of cephalon strongly curved backward on approaching the genal angles. Magnification: X 1½. Eden. Covington, Kentucky. Same specimens as in Bassler, Maryland Geol. Surv., Cambrian and Ordovician, 1919, p. 334, pl. 56, figs. 15, 14. (Page 238.)

FIGURE 13. *Triarthrus eatoni* Hall. Entire individual. Utica shale, Rome, New York. Copied after Beecher, but with all appendages omitted. For latter *see* Zittel-Eastman Text-book of Paleontology, 1913, p. 700, fig. 1342. (Page 240.)

FIGURE 14. *Calymene retrorsa minuens* Foerste. Enrolled individual. Magnification: X 1½. Richmond, Indiana. Whitewater member, Richmond. (Page 247.)

FIGURE 15. *Calymene retrorsa* Foerste. Enrolled individual, with rounded genal angles. Silver creek, east of Dunlapsville, Indiana. Middle or Clarksville division, Waynesville member, Richmond. Type specimen. Bull. Denison Univ., 16, 1910, p. 85, pl. 3, fig. 19. *See also* Plate XLII, figure 2. (Page 247.)

FIGURE 16. *Cryptolithus tesselatus* Green. *a*, dorsal view of cephalon; *b*, anterior view of same. Glabella and lateral lobes very prominent. Jacksonburg, New Jersey, Jacksonburg member, Trenton. Weller, New Jersey Geol. Surv. 3, Paleozoic Faunas, 1903, p. 192, pl. 14, figs. 3, 4. (Page 235.)

FIGURE 17. *Cryptolithus bellulus* (Ulrich). Entire individual, young, without genal spines. Magnification: X 4½. Covington, Kentucky. Eden. Bassler, Maryland Geol. Surv., Cambrian and Ordovician, 1919, p. 333, pl. 56, fig. 6. (Page 237.)

Plate No. XLV

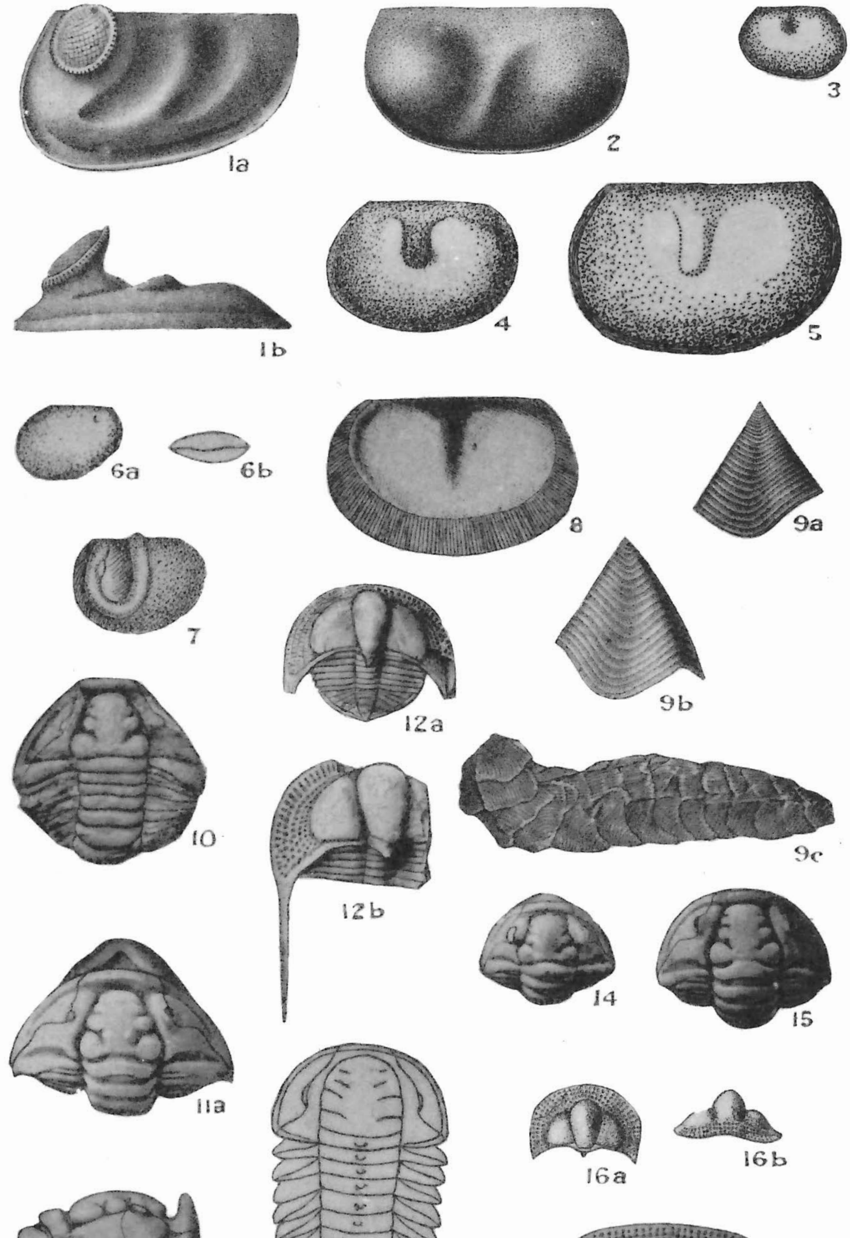


Plate XLVI

Figure 1. *Leperditia manitoulinensis* sp. nov. *a, b,* right valves; *c, d,* left valves. *a, c, d,* magnification: X 2. *b,* magnification: X 1½. No. 8520, Clay cliffs. Richmond. (Page 250.)

Figure 2. *Bythocypris cylindrica* (Hall). Right valve, specimen *e* on slab No. 8583, associated with *Drepanella richardsoni canadensis.* Magnification: X 16. Four miles northwest of Meaford, section VIII, lot 24, locality 1, Queenston shale member, Richmond. (Page 255.)

Figure 3. *Primitia lativia* Ulrich. Right valve. Specimen *c* on slab No. 8583, associated with *Drepanella richardsoni canadensis.* Magnification: X 16. Four miles northwest of Meaford, section VIII, lot 24, locality 1; Queenston shale member, Richmond. (Page 254.)

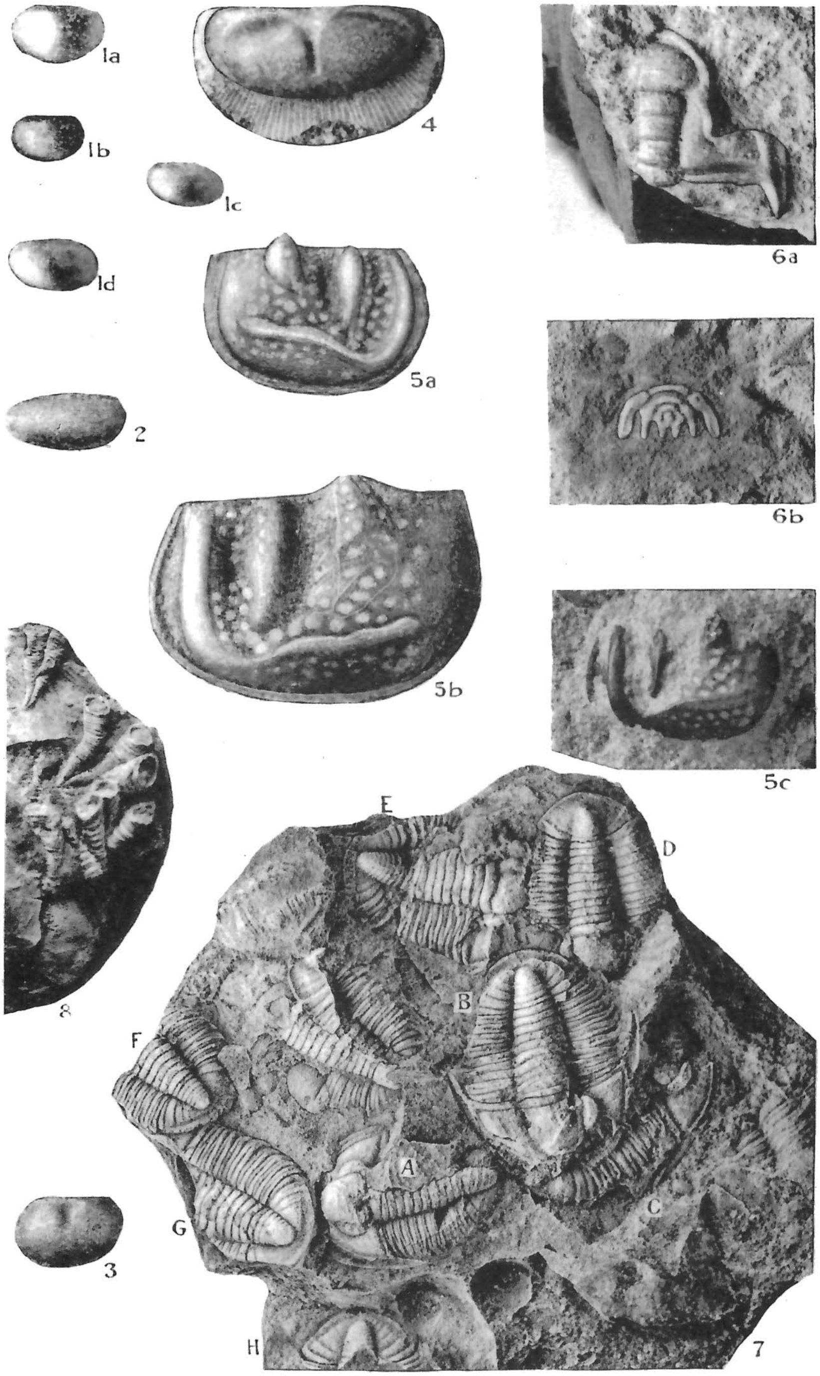
Figure 4. *Eurychilina striatomarginata* (Miller). Valve, with the upper anterior and upper posterior parts of the marginal rim not preserved. Magnification: X 16. Four miles northwest of Meaford, in section VIII, lot 24. Queenston shale member, Richmond. (Page 253.)

Figure 5. *Drepanella richardsoni canadensis* Ulrich. *a,* left valve. *b,* right valve. *c,* same specimen as *b,* before cleaning, to show the relative prominence of the different lobes and ridges. *a, b,* magnification: X 16. *c,* X 10. Four miles northwest of Meaford, in section VIII, lot 24, locality 1, Queenston shale member, Richmond. (Page 252.)

Figure 6. *Ceraurinus marginatus* Barton. *a,* fragment of glabella with fixed cheek. *b,* pygidium. *a,* magnification: X 1½. *b,* X 2. No. 8555, 3 miles southwest of Little Current. Richmond. (Page 248.)

Figure 7. *Proetus chambliensis* Foerste. *a, b, c,* complete individuals, the latter partly exposed, showing the genal spines; glabella preserved best in *a.* Neck ring seen best in *d* and *c.* Pygidium shown well by *e, f,* and *g.* Curvature of the extremities of the pleural segments seen best in *g.* Magnification: X 2. No. 8435, Chambly Canton. *Proetus* zone, Lorraine. (Page 243.)

Figure 8. *Cornulites* cf. *flexuosus* (Hall). Numerous specimens adnate laterally to a specimen of *Whitella.* Nicolet River section, Richmond, Waynesville member. (Page 77.)


1a
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