

CAMBRIAN BIVALVED CRUSTACEA OF THE ORDER CONCHOSTRACA

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INTRODUCTION

The present work is the outgrowth of investigations of the Paleozoic Ostracoda pursued by the authors as opportunity offered. In the course of these studies a critical comparison with the Cambrian species referred by authors to the Ostracoda became desirable. Most of these Cambrian bivalved species have been described in the papers published by Dr. G. F. Matthew on the Cambrian faunas of New Brunswick and Nova Scotia. The types of Doctor Matthew's species are now in the collections of the Royal Ontario Museum of Paleontology at Toronto. Upon application to the Museum authorities some years ago, and through the courtesy of Prof. W. A. Parks, the described specimens were very kindly sent to us at Washington for restudy.

When, at that time, Dr. Charles D. Walcott learned that the types of Matthew's species of bivalved crustacea were in our hands, he suggested that we include in our studies the abundant material of a similar nature contained in the unrivaled collection of Cambrian fossils in the United States National Museum. This additional task being accepted, the material in hand had become so nearly a complete representation of the smaller bivalved crustacea (Conchostraca) of the American Cambrian that its treatment assumed the character of a monograph rather than the brief notes on the supposed Ostracoda described by Matthew.

It should be said that we have been especially careful in the matter of illustrations. With very few exceptions the new figures are all photographs that have been touched up just enough to attain that desirable medium stage between the authors' interpretation and the

untouched photograph. Practically all of the material studied occurs in a dark matrix, and it was necessary to whiten the specimens by the ammonium-chloride process before suitable photographs could be secured. This process has also proved almost invaluable in the study of the specimens, for by the application of the thin, smooth, white coating of ammonium chloride characters which are obscure in the unwhitened specimen flash out into relief.

In the following pages we are compelled to record mistakes due mainly to incomplete preparation of material, all of which might have been avoided had some process for clearing up the specific characters been available. In some cases the posterior side was mistaken for the dorsal edge of the valve; frequently the outlines of the valves were incorrectly figured, the true edges being hidden under the matrix, as subsequent investigation showed. Even when perfectly prepared great care must be exercised in the study of these small crustacea, for their thin, flexible, and membranaceous shells are very liable to distortion or crushing. Numerous specimens are sometimes necessary to determine the true form of a species, and in this respect, as noted above, the present writers have been particularly fortunate in having at their service the great Cambrian collection accumulated by Doctor Walcott during a half century of unremitting effort.

As before stated, only the small ostracodelike bivalved crustacea of the Cambrian are considered in this paper. The great majority of the species are arranged in three closely related families, the Bradoriidae, Beyrichonidae, and Indianidae, while the remaining forms are referred to the recent Limnadiidae or have been left uncertain. Our studies upon these crustacea were well under way in 1913, so that the junior author was then able to definitely place these so-called Cambrian Ostracoda in the Order Conchostraca of the old division Phyllopora in his discussion of the Branchiopoda in the second edition of the Zittel-Eastman Textbook of Paleontology.

The larger Cambrian crustacea classified under *Isoxys*, *Hymenocaris*, and various genera proposed by Walcott are not considered in the present paper, but their position in the classification is indicated in the table on a succeeding page.

The Cambrian bivalve crustacea referred by Matthew and others to the Ostracoda certainly do not belong to that superorder. In all of the forms studied by us, with the exception possibly of certain species placed in the emended genus *Indiana*, the main muscle spot is located close to the anterocardinal angle just behind and beneath the ocular tubercle, whereas in the Ostracoda what is regarded as the corresponding scar is located somewhere near the middle of the valves. In at least one of the species of *Indiana*—*I. primaeva* (*Leperditia? primaeva*, Matthew)—an obscure subcircular scar is located very near the center of the valves. In all, however, the composition of

the shell is different, being thinner, more membranaceous, often flexible, and, if not strictly corneous, at least less calcareous than in the Ostracoda. Again, the valves are not so completely separated, there being, indeed, some reason for believing that the valves were always tightly joined along the back, often perhaps by fusion of the cardinal edges. In the Ostracoda the valves are always completely separated, the hingement along the back being effected by mere overlaps or by means of interlocking bars or teeth. In the Bradoriidae, finally, the margins of the valves, except along the back, are apart, the edges being so opposed that a narrow slit separates them. A somewhat similar condition occurs among Ostracoda only in the Cypridinidae in which the closed valves leave an incision and often a keyhole-like slit beneath the anterior "hook."

For the reasons mentioned we are confident that the Bradoriidae and allied Cambrian crustacea are not true Ostracoda. However, as they precede the Ostracoda in time, it is quite probable that the latter were derived from the earlier Bradoriidae and Beyrichonidae. That they stand in such relationship is indicated by the fact that the Leperditiiidae, the oldest representatives of the true Ostracoda, present more resemblances to these Cambrian bivalves than can be seen, with the exception possibly of the Cypridinidae, in any of the succeeding genera of the order. The Cypridinidae in that case may represent a reversion to ancestral characteristics—a condition indicated in Carboniferous representatives of other classes of organisms.

The correct classification of the small Cambrian bivalved crustacea is a difficult question. If the superorder Branchiopoda were to include the Phyllocarida as an order or were considered as closely allied, we would not hesitate to place them in the same general association, as we are impressed with the view that these Cambrian forms are an early phase or offshoot of the stock from which the Branchiopoda and Phyllocarida on the one hand and the Ostracoda on the other were derived.

To-day the term Branchiopoda is employed as a superorder to include the three distinct orders Anostraca, Notostraca, and Conchostraca, formerly considered as groups of the old division Phyllopoda, and a fourth order Cladocera, while the superorder Malacostraca contains all the higher crustacea with the Phyllocarida as its first division. The dorsal nodes and ridges marking the valves of the Bradoriidae and Beyrichonidae suggest closer relationship with the usually much larger Phyllocarida than with the typical fossil Phyllopoda (as *Estheria* and *Leaia*) of the order Conchostraca whose average size is about as in their supposed Cambrian progenitors. Perhaps this supposed relationship is only a case of parallel development, but at any rate it is obvious that until the body segments and appendages of these particular families have been discovered their exact classifica-

tion must be only provisional. Tentatively, therefore, we will refer them to the order Conchostraca of the superorder Branchiopoda.

In the table below we give our present idea of the classification of the Conchostraca and of the Cambrian and allied genera of related branchiopod crustacea.

CLASSIFICATION OF CAMBRIAN CONCHOSTRACA AND ALLIED
GENERA

CLASS CRUSTACEA

SUBCLASS EUCRUSTACEA

Superorder BRANCHIOPODA Latreille (PHYLLOPODA, part)

Order ANOSTRACA Sars

Opabinia, *Leancoilia*, *Yohioia*, and *Bidentia*, all of Walcott and from the Middle Cambrian of British Columbia.

Order NOTOSTRACA Sars

Protocaris Walcott; Lower Cambrian, Vermont.

Ribeiria Sharpe and *Ribeiriella* Shubert and Waagen; Canadian and Early Ordovician of Europe and America.

Apus Latreille, Trias-Recent; *Lepidurus* Leach, Recent.

Burgessia Walcott; Middle Cambrian of British Columbia.

Isoxys Walcott; Cambrian.

Euchasma, *Eopteria*, and *Ischyrina* of Billings, and *Technophorus*, Miller; Canadian, Ordovician and Early Silurian.

Order CONCHOSTRACA Sars

Family BRADORIIDAE Matthew

Bradoria Matthew (*Bradorona* Matthew); Lower and Middle Cambrian.

Walcottella, new genus; Middle Cambrian.

Family BEYRICHONIDAE, new family

Beyrichona Matthew (*Escasona* Matthew); Lower and Middle Cambrian.

Sellula Wiman; Lower Cambrian, Sweden.

Ahuta Matthew; Lower and Middle Cambrian.

Eremos Westergaard; Canadian of Sweden.

Hipponicharion Matthew; Lower and Middle Cambrian.

Polyphyma Groom; Middle and Upper Cambrian.

Family INDIANIDAE, new family

Indiana Matthew; Lower and Middle Cambrian.

Dielymella, new genus; Lower and Middle Cambrian.

Mononotella, new genus; Lower Cambrian.

Family LIMNADIIDAE Baird

Estheria Ruppel; Devonian-Pleistocene.

Leia Jones; Carboniferous of Europe and North America.

Estheriella Weiss; Permian of Russia and Saxony.

Schizodiscus Clarke; Middle Devonian of New York.

Lepiditta Matthew; Lower and Middle Cambrian.

Fordilla Walcott; Lower Cambrian.

Modioloides Walcott; Lower Cambrian.

Lepidilla Matthew; Middle Cambrian.

Superorder MALACOSTRACA Latreille

Order PHYLLOCARIDA Packard

Suborder HYMENOCARINA Clarke

Hymenocaris Salter; Cambrian.

Anomalocaris Whiteaves, *Hurdia*, *Tuzoia*, *Odaravia*, *Fieldia*, *Carnarvon*, and *Waptia* all of Walcott from the Middle Cambrian of British Columbia.

Suborder CERATIOCARINA Clarke

Ceratiocaris McCoy, *Nothozoe* Barrande; Ordovician, etc.

Caryocaris Salter; Cambrian, Ordovician.

Suborder DISCINOCARINA Clarke

Shafferia Walcott; Cambrian.

Aptychopsis Barrande; Cambrian, Ordovician.

The following section shows the sequence of formations in Cape Breton and New Brunswick, the correlation of the zones distinguished by Matthew with the Walcott locality numbers as described in his Cambrian Brachiopod Monograph, and the fauna of Conchostraca in the various zones.

SECTION, GIVING FORMATIONS WITH FAUNAS OF CONCHO-
STRACA CAPE BRETON AND NEW BRUNSWICK*Canadian:*

Upper Bretonian (Matthew, 1903).

Division C3c2 (*Asaphellus* zone).

Division C3c (*Dictyonema* zone).

Ozarkian:

Lower Bretonian.

Division C3b (*Peltura* zone).

Division C3a (*Parabolina* zone).

Cambrian:

Middle Cambrian (St. John group—Johannian division of Matthew, 1903.)

Division C2c.

Division C2b (*Forchhammeri* zone 3h, 3i, 10s, 307g) *Beyrichona triceps*, *Hipponicharion confluens*, *H. parvum*, *H. plicatum*.

Division C2a.

Middle Cambrian (St. John group—Acadian division of Matthew, 1903, *Paradoxides* zones).

Division C1d (*Lepiditta curta*).

Division C1c1, C1c2 (2l, 2s) (*Aluta flexilis*, *Beyrichona tinea*, *Indiana dermatoides*, *I. acadica*, *I. matthewi*, *I. primaeva*, *Lepiditta alata*, *L. auriculata*, *Lepidilla anomala*.)

Lower Cambrian (St. John group, Hanfordian division of Van Ingen, 1914, *Protolenus* zone)

Division C1b5.

Division C1b4 (*Beyrichona papilio*, *B. tinea*).

Division C1b3 (2i, 2k) (*Beyrichona benepuncta*, *B. cambrica*, *B. minor*, *B. oculata*, *B. papilio*, *B. rotundata*, *B. tinea*, *B. tinea planata*, *B. tinea triangula*, *Hipponicharion cavatum*, *H. minus*, *Indiana dermatoides*, *I. lippa*, *I. longula*, *I. matthewi*, *I. primaeva*, *I. pyriformis*, *I. secunda*, *Lepiditta sigillata*, *Mononotella fusiformis*).

Division C1b2 (2h, 301) (*Beyrichona ovata*, *B. papilio*, *B. rotundata*, *B. tinea*, *B. tinea planata*, *Entomidella buprestis*, *Indiana secunda*, *Bradoria primaeva*).

Division C1b1 (2g) (*Beyrichona tinea planata*, *Bradoria aurora*, *B. robusta*, *B. steadi*, *Leperditia ventricosa*, *Hipponicharion eos*, *H. cavatum*).

Lower Cambrian (Etcheminian, Matthew, 1903).

Division E3f (13m, 13n, 344d) (*Beyrichona rutellum*, *Bradoria acuta*, *B. robusta*, *B. scrutator*, *Indiana lippa*, *Mononotella fusiformis*).

Division E3e (13n') (*Bradoria acuta*, *B. ovalis*, *B. robusta*, *B. rugulosa*, *B. scrutator*, *B. spectator*, *B. vigilans*, *Indiana lippa*, *Schmidtella pervetus*).

Division E3d (13n'', 344b) (*Bradoria acuta*, *B. benepuncta*, *B. elongata*, *B. obesa*, *B. robusta*, *B. scrutator*, *B. spectator spinosa*, *B. vigilans*, *B. vigilans concentrica*).

Division E3c (344a) (*Bradoria scrutator*, *B. acuta*).

Cambrian—Continued.

Lower Cambrian—Continued.

Division E3b.

Division E3a (13l, 13l') (*Bradoria acuta*, *B. curta*).Division E2c (13e, 344l) (*Bradoria acuta*, *B. rugulosa*)Division E2b (10p, 10p', 10p'', 10q) (*Bradoria acuta*, *B. benepuncta*, *B. benepuncta spissa*, *B. elongata*, *B. medialis*, *B. obesa*, *B. ovalis*, *B. perspicator*, *B. robusta*, *B. spectator*, *B. vigilans*).Division E2a (13d, 13d', 13d'', 13g) (*Bradoria benepuncta*, *B. perspicator*, *B. robusta*, *B. rugulosa*).Division E1e (344h) (*Bradoria spectator spinosa*, *B. ovalis*).Division E1d (13t', 344d, 344e) (*Bradoria acuta*, *B. benepuncta*, *B. concinna*, *B. obesa*, *B. perspicator*, *B. robusta*, *B. spectator*, *B. subquadrata*).Division E1c (344g) (*Bradoria acuta*, *B. benepuncta*, *B. concinna*, *B. obesa*, *B. ornata*, *B. robusta*, *B. rugulosa*, *B. perspicator*, *B. spectator*).Division Eb (13t, 13t', 344k) (*Bradoria acuta*, *B. benepuncta*, *B. benepuncta spissa*, *B. obesa*, *B. robusta*, *B. robusta longula*, *B. rugulosa*, *B. spectator*).

Division E1a.

Lower Cambrian (Coldbrookian, Matthew, 1903) (13k, 344f) (*Bradoria ovalis prima*, *Escasona ingens*).

An alphabetic list with cross references and the geologic occurrence of the species treated in this paper follows.

ALPHABETIC LIST OF NAMES APPLIED TO CAMBRIAN CONCHOSTRACA

Aluta Matthew.*Aluta bergeroni* (Walcott)-----Middle Cambrian (China).*Aluta douvillei* (Mansuy)-----Cambrian (Yunnan).*Aluta enyo* (Walcott)-----Middle Cambrian (China).*Aluta eros* (Walcott)-----Middle Cambrian (China).*Aluta flexilis* Matthew-----Middle Cambrian (Acadian, C1C2).*Aluta fragilis* (Walcott)-----Middle Cambrian (China).*Aluta hollii* (Jones)-----Cambrian-Menevian (Wales).*Aluta primordialis* (Linnarsson)-----Middle Cambrian (Sweden).*Aluta rimulata*, new species-----Middle Cambrian (British Columbia).*Aluta rotundata* (Walcott)-----Lower Cambrian (New York).*Aluta stereope* (Walcott)-----Middle Cambrian (China).*Aluta troyensis* (Ford)-----Lower Cambrian (New York).*Aluta woodi* (Walcott)-----Middle Cambrian (China).*Aparchites anderssoni* Wiman=*Indiana anderssoni*.*Aparchites fennicus* Wiman=*Bradoria fennicus*.*Aparchites robustus* Matthew=*Bradoria robusta*.*Aparchites secunda* Matthew=*Indiana secunda*.*Aristozoe rotundata* Walcott=*Aluta rotundata*.

- Aristozoe troyensis* Ford = *Aluta troyensis*.
Beyrichia angelini Barrande = *Polyphyma angelini*.
Beyrichia angelini armata Gronwall = *Polyphyma armata*.
Beyrichia hollii Jones = *Aluta hollii*.
Beyrichia? primaeva Matthew = *Bradoria primaeva*.
Beyrichia triceps Matthew = *Beyrichona triceps*.
Beyrichona Matthew.
Beyrichona alia Wiman..... Lower Cambrian (Sweden).
Beyrichona faba Wiman..... Lower Cambrian (Sweden).
Beyrichona gevalensis Wiman..... Lower Cambrian (Sweden).
Beyrichona ovata (Matthew)..... Lower Cambrian (Hanfordian, C1b2).
Beyrichona papilio Matthew..... Lower Cambrian (Hanfordian, C1b2-C1b4).
Beyrichona planata Matthew = *Beyrichona tineae planata*.
Beyrichona rotundata Matthew..... Lower Cambrian (Hanfordian, C1b2, C1b3).
Beyrichona? rutellum (Matthew)..... Lower Cambrian (Etcheminian, E3f).
Beyrichona tineae Matthew..... Lower Cambrian (Hanfordian, C1b2-C1b4).
Beyrichona tineae planata (Matthew)..... Lower Cambrian (Hanfordian, C1b1-C1b3).
Beyrichona tineae triangula (Matthew)..... Lower Cambrian (Hanfordian, C1b3).
Beyrichona triangula Matthew (part) = *B. tineae triangula*.
Beyrichona triangula Matthew (part) = *Beyrichona papilio*.
Beyrichona triceps (Matthew)..... Middle Cambrian (Johannian, C2b).
Bradoria Matthew.
Bradoria acuta (Matthew)
 Lower Cambrian (Etcheminian, E1b-E1d, E2b, E2c, E3a, E3c, E3f).
Bradoria aurora (Matthew)..... Lower Cambrian (Hanfordian, C1b1).
Bradoria benepuncta (Matthew)
 Lower Cambrian (Hanfordian, C1b3; Etcheminian, E1b, E1d, E2a, E2b, E3d).
Bradoria benepuncta spissa, new variety... Lower Cambrian (Etcheminian, E1b, E2b).
Bradoria bergeroni Walcott = *Aluta bergeroni*.
Bradoria cambrica (Matthew)..... Lower Cambrian (Hanfordian, C1b3).
Bradoria concinna (Matthew)..... Lower Cambrian (Etcheminian, E1c, E1d).
Bradoria curta, new species..... Lower Cambrian (Etcheminian, E3a).
Bradoria douvillei Mansuy = *Aluta douvillei*.
Bradoria elongata, new species..... Lower Cambrian (Etcheminian, E2b, E3d).
Bradoria enyo Walcott = *Aluta enyo*.
Bradoria eros Walcott = *Aluta eros*.
Bradoria fennicus (Wiman)..... Cambrian (Sweden).
Bradoria fragilis Walcott = *Aluta fragilis*.
Bradoria hicksi (Jones)..... Cambrian (Wales).
Bradoria medialis, new species..... Lower Cambrian (Etcheminian, E2b).
Bradoria minor (Matthew)..... Lower Cambrian (Hanfordian, C1b3).
Bradoria nitida (Wiman)..... Cambrian (Sweden).
Bradoria obesa (Matthew)..... Lower Cambrian (Etcheminian, E1b-E1d, E2b, E3d).
Bradoria observator Matthew = *B. perspicator*.
Bradoria oculata (Matthew)..... Lower Cambrian (Hanfordian, C1b3).
Bradoria ornata (Matthew)..... Lower Cambrian (Etcheminian, E1c).
Bradoria ovalis (Matthew)..... Lower Cambrian (Etcheminian, E1e, E2b, E3e).
Bradoria ovalis mut prima Matthew..... Lower Cambrian (Coldbrookian).
Bradoria perspicator (Matthew)..... Lower Cambrian (Etcheminian, E1d, E2a, E2b).
Bradoria primaeva (Matthew)..... Lower Cambrian (Hanfordian, C1b).
Bradoria robusta (Matthew)
 Lower Cambrian (Hanfordian, C1b; Etcheminian, E1b-E1d, E2a, E2b, E3d-E3f).
Bradoria robusta longula, new variety... Lower Cambrian (Etcheminian, E1b).

- Bradoria rugosa* Matthew = *Bradoria robusta*.
Bradoria rugulosa Matthew
 Lower Cambrian (Etcheminian, E1b, E1c, E2a, E2c, E3e).
Bradoria scrutator Matthew..... Lower Cambrian (Etcheminian, E3c-E3f).
Bradoria spectator (Matthew)
 Lower Cambrian (Etcheminian, E1c, E1d, E2b, E3e).
Bradoria spectator spinosa (Matthew) Lower Cambrian (Etcheminian, E3d, E1e).
Bradoria? steadi (Matthew)..... Lower Cambrian (Hanfordian, C1b1).
Bradoria stereope Walcott = *Aluta stereope*.
Bradoria subquadrata, new name (*Bradorona spectator acuta* Matthew)
 Lower Cambrian (Etcheminian, E1d).
Bradoria tontoensis, new species..... Middle Cambrian (Arizona).
Bradoria vigilans Matthew..... Lower Cambrian (Etcheminian, E2b, E3d, E3e).
Bradoria vigilans (part) = *Bradoria obesa*.
Bradoria vigilans concentrica, new variety... Lower Cambrian (Etcheminian, E3d).
Bradoria vigilans obesa Matthew = *Bradoria obesa*.
Bradoria woodi Walcott = *Aluta woodi*.
Bradorona Matthew = *Bradoria*.
Bradorona nitida Wiman = *Bradoria nitida*.
Bradorona observator Matthew = *Bradoria perspicator*.
Bradorona observator benepuncta Matthew = *Bradoria benepuncta*.
Bradorona observator mut laevis Matthew = *Bradoria rugulosa*.
Bradorona observator mut ligata = *Bradoria scrutator* and *B. acuta*.
Bradorona perspicator Matthew = *Bradoria perspicator*.
Bradorona perspicator mut magna Matthew = *Bradoria robusta*.
Bradorona perspicator mut major Matthew = *Bradoria robusta*.
Bradorona perspicator mut maxima Matthew = *Bradoria robusta*.
Bradorona spectator Matthew = *Bradoria spectator*.
Bradorona spectator var. acuta Matthew = *Bradoria subquadrata*.
Bradorona spectator mut aequata Matthew = *Bradoria spectator spinosa*.
Bradorona spectator mut spinosa Matthew = *Bradoria spectator spinosa*.
Bythocypris polita Steusloff = *Lepiditta polita*.
Dielymella, new genus.
Dielymella appressa, new species..... Middle Cambrian (Arizona).
Dielymella brevis, new species..... Lower Cambrian (Vermont).
Dielymella dorsalis, new species..... Middle Cambrian (Arizona).
Dielymella nasuta, new species..... Middle Cambrian (Arizona).
Dielymella recticardinalis, new species..... Middle Cambrian (Arizona).
Dielymella recticardinalis angustata, new variety.... Middle Cambrian (Arizona).
Entomidella? buprestis (Salter)..... Cambrian (Wales); Hanfordian, C1b2).
Entomis buprestis Jones = *Entomidella buprestis*.
Eremos Westergaard.
Eremos bryograptorum Westergaard..... Canadian (Sweden).
Escasona Matthew = *Beyrichona*.
Escasona? ingens Matthew. Not recognizable. Lower Cambrian (Coldbrookian).
Escasona? ovata Matthew = *Beyrichona ovata*.
Escasona rutellum Matthew = *Beyrichona? rutellum*.
Escasona? vetus Matthew. Not recognizable
 Lower Cambrian (Etcheminian; E1d).
Fordilla Walcott.
Fordilla troyensis Walcott..... Lower Cambrian (New York).
Hipponicharion Matthew.
Hipponicharion cavatum..... Lower Cambrian (Hanfordian, C1b1-C1b3).
Hipponicharion confluens, new species..... Middle Cambrian (Acadian, C2b1).

- Hipponicharion eos* Matthew Lower Cambrian (Hanfordian, C1b1).
Hipponicharion matthewi Wiman Lower (Middle?) Cambrian (Sweden).
Hipponicharion minus Matthew Lower Cambrian (Hanfordian, C1b3).
Hipponicharion parvum, new species Middle Cambrian (Acadian, C2b).
Hipponicharion plicatum, new species Middle Cambrian (Cape Breton).
Indiana Matthew.
Indiana acadica (Matthew) Middle Cambrian (Acadian, C1c1).
Indiana anderssoni Wiman Cambrian (Sweden).
Indiana cambrensis (Hicks) Cambrian (Wales).
Indiana curta, new species Middle Cambrian (Arizona).
Indiana dermatoides (Walcott)
 Lower Cambrian (Hanfordian, C1b3 and Georgian of New York).
Indiana faba, new species Middle Cambrian (Arizona).
Indiana faba intermedia, new variety Middle Cambrian (Arizona).
Indiana fusiformis Matthew = *Mononotella fusiformis*.
Indiana impressa, new species Middle Cambrian (Arizona).
Indiana labiosa, new species Middle Cambrian (British Columbia).
Indiana lentiformis Cobbold Lower Cambrian (England).
Indiana lippa Matthew
 Lower Cambrian (Hanfordian, C1b3; Etcheminian, E3e, E3f).
Indiana longula, new species Lower Cambrian (Hanfordian, C1b3).
Indiana matthewi, new species
 Lower Cambrian (Hanfordian, C1b3); Middle Cambrian (Acadian, C1c).
Indiana minima Wiman Middle Cambrian (Sweden).
Indiana ovalis Matthew = *Bradoria ovalis*.
Indiana ovalis prima Matthew = *Bradoria ovalis*.
Indiana primaeva (Matthew)
 Lower Cambrian (Hanfordian, C1b3); Middle Cambrian (Acadian, C1c).
Indiana pyriformis (Matthew) Lower Cambrian (Hanfordian, C1b3).
Indiana robusta Matthew = *Bradoria robusta*.
Indiana secunda (Matthew) Lower Cambrian, Hanfordian, C1b2).
Indiana solvensis (Jones) Cambrian (Wales).
Indiana suberecta, new species Lower Cambrian (New York).
Isochilina sweeti Chapman Upper Cambrian (Australia).
Isochilina ventricosa Matthew = *Leperditia? ventricosa*.
Leperditia buprestis Salter = *Entomidella buprestis*.
Leperditia cambrensis Hicks = *Indiana cambrensis*.
Leperditia capsella Chapman Upper Cambrian (Australia).
Leperditia dermatoides Walcott = *Indiana dermatoides*.
Leperditia ebenina Dwight Middle Cambrian (New York).
Leperditia hicksii Jones = *Bradoria hicksii*.
Leperditia? minor Matthew = *Bradoria minor*.
Leperditia primaeva Matthew = *Indiana primaeva*.
Leperditia primordialis Linnarsson = *Aluta primordialis*.
Leperditia punctatissima Salter = *Entomidella? buprestis*.
Leperditia? rugosa Matthew = *Bradoria robusta*.
Leperditia cf. solitaria Barrande Cambrian (Massachusetts).
Leperditia solvensis Jones = *Indiana solvensis*.
Leperditia? steadi Matthew = *Bradoria steadi*.
Leperditia tatei Chapman Upper Cambrian (Australia).
Leperditia troyensis Ford = *Aluta troyensis*.
Leperditia? ventricosa (Matthew) Lower Cambrian (Hanfordian, C1b1).
Leperditia vezata Hincks Cambrian-Menevian (Wales).
Lepidilla Matthew.

- Lepidilla anomala* Matthew.....Middle Cambrian (Acadian, C1c2).
Lepidilla Matthew.
Lepidilla alata Matthew.....Middle Cambrian (Acadian, C1c2).
Lepidilla auriculata Matthew.....Middle Cambrian (Acadian, C1c1).
Lepidilla curta Matthew.....Middle Cambrian (Acadian, C1d1).
Lepidilla polita (Steusloff).....Middle Cambrian drift (Germany).
Lepidilla sigillata Matthew.....Lower Cambrian (Hanfordian, C1b3).
Modioloides Walcott.
Modioloides prisca Walcott.....Lower Cambrian (New York).
Modiolopsis thecoides Matthew.....Lower Cambrian (Etcheminian), Newfoundland.
Mononotella, new genus.
Mononotella fusiformis (Matthew).
Lower Cambrian (Hanfordian, C1b3; Etcheminian, E3f).
Nothozoe? vermontana Walcott (part) = *Dielymella brevis*.
Polyphyma Groom.
Polyphyma angelini (Barrande).....Upper Cambrian (Sweden).
Polyphyma armata (Grönwall).....Middle Cambrian (Denmark).
Polyphyma lapworthi Groom.....Cambrian (England).
Polyphyma marginata, new species.....Upper Cambrian (Newfoundland).
Primitia acadica Matthew = *Indiana acadica*.
Primitia aurora Matthew = *Bradoria aurora*.
Primitia? fusiformis Matthew = *Mononotella fusiformis*.
Primitia oculata Matthew = *Bradoria oculata*.
Primitia pyriformis Matthew = *Indiana pyriformis*.
Primitia simplex lloydiana Jones.....Cambrian (Newfoundland).
Primitia simplex milneana Jones.....Cambrian (Newfoundland).
Primitia simplex sanctojohannensis Jones.....Cambrian (Newfoundland).
Primitia solvensis Jones = *Indiana solvensis*.
Schmidtella acuta Matthew = *Bradoria acuta*.
Schmidtella cambrica Matthew = *Bradoria cambrica*.
Schmidtella? pervetus Matthew = Unrecognizable.
Lower Cambrian (Etcheminian, E3e).
Schmidtella? pervetus mut *concinna* Matthew = *Bradoria concinna*.
Sellula Wiman.
Sellula fallax Wiman.....Lower Cambrian (Sweden).
Walcottella, new genus.
Walcottella apicalis, new species.....Middle Cambrian (Arizona).
Walcottella breviscula, new species.....Middle Cambrian (Arizona).
Walcottella concentrica, new species.....Middle Cambrian (Arizona).
Walcottella leperditoides, new species.....Middle Cambrian (Arizona).
Walcottella limatula, new species.....Middle Cambrian (Arizona).
Walcottella longula, new species.....Middle Cambrian (Arizona).
Walcottella nitida, new species.....Middle Cambrian (Arizona).
Walcottella oblonga, new species.....Middle Cambrian (Arizona).
Walcottella obsoleta, new species.....Middle Cambrian (Arizona).
Walcottella pulchella, new species.....Middle Cambrian (Arizona).
Walcottella scitula, new species.....Middle Cambrian (Arizona).
Walcottella subtruncata, new species.....Middle Cambrian (Arizona).
Walcottella ventrosa, new species.....Middle Cambrian (Arizona).

SYSTEMATIC DESCRIPTIONS

Class CRUSTACEA

Superorder BRANCHIOPODA Latreille

Order CONCHOSTRACA Sars

Family BRADORIIDAE Matthew

Bivalved Conchostraca equivalved or possibly slightly inequivalved, with a straight hinge line. Surface closely punctate, otherwise even except for a more or less conspicuous node, the ocular tubercle, located near the antero-dorsal corner (*Bradoria*) and of an additional eminence in the median third of the length, believed to be the muscle spot (*Walcottella*). Shell structure calcareo-corneous to phosphatic.

Genus BRADORIA Matthew

Bradoria MATTHEW, Bull. Nat. Hist. Soc. New Brunswick, No. 18, 1899, p. 204; Canadian Rec. Sci., vol. 8, 1902, p. 451.—JONES Geol. Mag., Dec. 4, 1902, p. 402, text fig. 5.—MATTHEW, Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 162 (genotype *B. scrutator* Matthew).

Bradورونا MATTHEW, Canadian Rec. Sci., vol. 8, 1902, p. 444.—JONES, Geol. Mag., Dec. 4, 1902, p. 402, text fig. 2.—MATTHEW, Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 156 (genotype *B. perspicator* Matthew).

(Including *Indiana* (part), *Schmidtella*, and *Leperditia* Matthew).

After a careful comparison of all the species referred by Matthew to *Bradoria*, to the subgenus *Bradورونا*, to *Schmidtella* and *Leperditia*, and in addition a number of undescribed species in the Walcott collection, we conclude there is absolutely no valid ground for either generic or subgeneric distinction between the several groups. The only difference between *Bradoria* and *Bradورونا* is that while in the former the ventral outline is rather broadly and almost uniformly curved, in *Bradورونا* it is more or less produced; hence more abruptly curved medially or at some point behind the middle. In consequence of this slight, and certainly not generic, difference, the proportionate height of the valves is less in *Bradoria* than in *Bradورونا*. It is a fact, however, that even in the most typical *Bradoria* (*B. scrutator*) the ventral outline is less broadly curved than presented in Matthew's figures of the species; and from this we pass by such gradual steps to *Bradورونا perspicator* and *B. spectator*, in which (of Matthew's species) the median production of the ventral outline is most conspicuous, that the observer can not fail to be impressed with the invalidity of the distinction.

Regarding the species referred by Matthew to *Leperditia*, namely *L. ? rugosa* and *L. minor*, and to *Schmidtella*, namely *S. pervetus*, *S.*

pervetus concinna, *S. cambrica*, and *S. acuta*, these agree in all essential respects with *Bradoria*. In the so-called Schmidtellae the form is short and tumid, but not more so than in certain species of *Bradorona* (as *B. obesa*). Except *Schmidtella* ? *pervetus concinna*, in which the ocular tubercle is barely distinguishable, all of the other species named in this paragraph have this tubercle more or less well developed. Variability in prominence of the "eye tubercle" in the Leperditiiidae, however, is so common and has been proved to be of such little consequence in the generic grouping of the species that a similar inconsequence is suggested for the variation of the corresponding tubercle in these Cambrian crustaceans. Indeed, as a study of abundant material in Doctor Walcott's collection shows, individuals even may vary considerably in the relative development of the "eye tubercle." Considering species, the possibility of duplication under separate generic heads was immediately suggested, and before we had progressed very far in our study of the Matthew types, such duplication was demonstrated. It was induced, in the cases in mind, sometimes by exaggerated values ascribed to nonessential variations in development, but oftener through imperfections in preservation or incomplete preparation of the specimens.

The genus *Indiana* is noted above as a synonym in part. But if it were insisted that when no genotype is designated the first species following the generic description is to be so regarded, the genus could not stand. The first species, namely, *Indiana ovalis*, is an unquestionable *Bradoria*, being in fact a close ally of *B. rugulosa* and *B. robusta*. In this case, however, we think it advisable to transfer the rank of genotype to *I. lippa* one of two or three clearly congeneric species referred to the genus when it was first described by Matthew. Restricted to these and similar species, *Indiana* is distinguished by its oval, smooth form and total absence of the ocular tubercle. The gap between the valves is greater, and this, together with the other differences, probably indicates peculiarities of more serious import than can be established now.

All of the species of *Bradoria* as here revised bear a single node, the ocular tubercle. This, while always close to the anterocardinal angle, varies considerably in prominence. Rarely it is barely distinguishable, but as a rule it is a conspicuous feature, and not infrequently the definition of its base is emphasized by a narrow depression extending in part or entirely around it. In most of the species the outline of the valves is more or less distinctly divisible into five unequal sides. The angles marking off these sides are sometimes sharp, never equally so, the ventral angle generally the least acute, and in some cases all but the two defining the upper and lower extremities of the truncated, narrow anterior end are practically obsolete. The narrowest of the five sides is terminated above by the

posterior extremity of the straight cardinal edge and constitutes the upper one-fifth to one-third of the posterior margin. This short dorso-posterior side is best defined in species in which the remainder of the posterior outline trends somewhat forward, and manifestly least distinct in species like *B. robusta*, in which the backward trend prevails also in the lower part of this portion of the outline. In a few cases, notably *B. acuta*, and in a less degree *B. benepuncta* and *B. scrutator*, the general outline in a side view of the valves conforms to that of a right-angled triangle, the dorsal edge being the vertical, the posterior the base, and the ventral side the hypotenuse. As a rule the transverse diameter exceeds the vertical, in one case (a new species for which the name *B. elongata* is suggested), the dimensions being to each other about as 2 to 1. In the other extreme (likewise represented by a new species for which the name *B. curta* is suggested) the vertical diameter is considerably greater than the transverse.

All of these variations in form, however, are closely knit together by intermediate phases, and as no genetic departure from the generic type maintained throughout the whole group seems to have been established, a wholly satisfactory subgeneric grouping of the species has so far failed to suggest itself. Still, it may prove that the following provisional arrangement of the species in sections is more natural than we believe at present.

- | | |
|---|---|
| <p>1. Section of <i>B. scrutator</i>:
 <i>B. scrutator</i> Matthew (genotype).
 <i>B. oculata</i> (Matthew).
 <i>B. vigilans</i> Matthew.
 <i>B. vigilans concentrica</i>, new variety.
 <i>B. benepuncta</i> (Matthew).
 <i>B. benepuncta</i> var. <i>spissa</i>, new variety.
 <i>B. medialis</i>, new species.
 <i>B. acuta</i> (Matthew).
 <i>B. subquadrata</i>, new name (= <i>B. scrutator acuta</i> Matthew).
 <i>B. elongata</i>, new species.</p> | <p>3. Section of <i>B. perspicator</i>:
 <i>B. perspicator</i> (Matthew).
 <i>B. spectator</i> Matthew.
 <i>B. spectator spinosa</i> (Matthew).
 <i>B. curta</i>, new species.</p> |
| <p>2. Section of <i>B. rugulosa</i>:
 <i>B. ovalis</i> (Matthew).
 <i>B. rugulosa</i> Matthew.
 <i>B. robusta</i> (Matthew).
 <i>B. robusta</i> var. <i>longula</i>, new variety.
 <i>B. tontoensis</i>, new species.</p> | <p>4. Section of <i>B. cambrica</i>:
 ? <i>B. obesa</i> (Matthew).
 ? <i>B. concinna</i> (Matthew).
 <i>B. cambrica</i> (Matthew).</p> <p>5. Miscellaneous species:
 <i>Schmidtella pervetus</i> Matthew.
 <i>Bradoria minor</i> Matthew.
 <i>Bradoria? stadi</i> Matthew.
 <i>Bradoria primaeva</i> (Matthew).
 <i>Bradoria aurora</i> Matthew.
 <i>Bradoria? ornata</i> Matthew.
 <i>Bradoria fennicus</i> (Wiman).
 <i>Bradoria nitida</i> (Wiman).
 <i>Bradoria hicksi</i> Jones.</p> |

BRADORIA SCRUTATOR Matthew

Plate 1, Figures 11, 12; Plate 3, Figure 11

Bradoria scrutator MATTHEW (part), Bull. Nat. Hist. Soc. New Brunswick, No. 18, 1899, p. 204, pl. 4, figs. 1a-1c; Canadian Record Sci., vol. 8, 1902, p. 451; Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 163, pl. 13, figs. 1a-1c.

Bradorona observator mut. *ligata* MATTHEW (part), Canadian Record Sci., vol. 8, 1902, p. 451, pl. 1, fig. 17; Geol. Surv. Canada Rept. Cambrian Rocks Cape Breton, 1903, p. 162, pl. 12, fig. 17.

The type lot of this species, the genotype, contains three specimens, A, B, and C.¹ The one marked A is mostly a cast of the interior of *Bradoria benepuncta*, both the outline and contour of the valve and the punctations of a small patch of remaining shell agreeing with that species. B and C are evidently conspecific, and C is the specimen used by Matthew in illustrating the species. Matthew's figure of the left valve of this specimen (pl. 1, fig. 11) gives a false impression of the true outline, the ventral portion of the specimen being somewhat obscured by matrix and the whole carapace crushed so as to straighten this side a trifle and to expose the cardinal edge of the opposite right valve. The true outline of the valves—at any rate of the right, should the two, as seems highly improbable, be unequal—is more nearly approximated by specimen B. This indicates that the posterior half is proportionately wider than it is represented in Matthew's figure.

The characteristics of the species, as indicated by this specimen are (1) the rather uniform rounding of the posterior end, (2) the comparative obsolescence of the postcardinal and postventral angles, (3) the far anterior location of the ocular tubercle, and (4) the relatively coarse pattern of its surface punctation, but an excellently preserved example in the Walcott collections from the type locality shows that the posterior outline is sharply rounded in the postventral part and appreciably angulated in both the anteroventral and the postdorsal parts. On the whole, then, the outline of *B. scrutator* is somewhat obscurely quadrangular, thus agreeing better with the other species of its section of the genus.

Bradorona observator ligata Matthew is regarded as a synonym of *Bradoria scrutator*. The collection contains two specimens of this "mutation," both imperfect. They are quite distinct, one (A) being the same as the types of *B. scrutator*, the other (B) being a more triangular carapace and marked by exceedingly fine punctae (much finer than in *B. scrutator*). Neither is closely related to the typical form of *B. observator*. The specimen A is evidently the original of Matthew's Figure 17 and is accepted as the true type. This conclusion is fortified by the fact that this specimen alone fits the description in having "punctation rather coarse." This specimen is a trifle wider in the direction of the vertical diameter than usual in typical examples of *B. scrutator*, but this difference is certainly not of specific, and, in our opinion, not even of varietal, importance. The

¹ The Matthew types have been carefully lettered when a species is represented by more than one specimen. In such cases, Doctor Matthew probably used all the specimens in formulating his descriptions. It will be noted that in the present work we have found it necessary to restrict his types to the figured specimens in practically all cases.

postventral outline also seems less sharply curved, but this is due to imperfect preservation of the edge. The feature relied on by Matthew is a constriction, or rather a depression, in the dorsal edge of the exposed valve; but as no corresponding depression occurs on the opposite valve, the peculiarity is regarded as accidental and not structural. Hence mutation *ligata* is ranked as a synonym of *B. scrutator*.

The second specimen, B, though not perfect, is still good enough to leave no doubt in our minds as to its identity with the types of *Schmidtella acuta*. These are of an unquestionable species of *Bradoria*, but were misinterpreted by Matthew, who regarded the posterior end as dorsal.

Occurrence.—Lower Cambrian (Upper Etcheminian, division E3c-E3f): Dugald Brook, Cape Breton, Nova Scotia. Walcott locality 13n'.

Plesiotype.—Cat. No. 50540, U.S.N.M.

BRADORIA OCLATA (Matthew)

Plate 1, Figures 13, 14

Primitia oculata MATTHEW, Trans. New York Acad. Sci., vol. 14, 1895, p. 136, pl. 8, figs. 2a, 2b.

Bradoria oculata MATTHEW, Bull. Nat. Hist. Soc. New Brunswick, No. 18; 1899, p. 204.

The figures of the type and only example of this species do the specimen much more than justice, it being crushed so that we hesitate to decide definitely as to its affinities. Apparently it is a close ally of *B. scrutator*, the surface punctae being about equal in number (they are smaller but thicker walled), the outline about the same, and the ocular tubercles close to the anterior extremity as in that species. Without better specimens, however, it would be unwise to either refer *B. oculata* to synonymy or to recognize it as a good species.

Occurrence.—Lower Cambrian (Hanfordian, division C1b3): Hanford Brook, St. John County, New Brunswick.

BRADORIA VIGILANS Matthew, s. s.

Plate 1, Figure 15

Bradoria vigilans MATTHEW (part) Bull. Nat. Hist. Soc. New Brunswick, No. 18, 1899, p. 205, pl. 4, figs. 2a-2c; Canadian Rec. Sci., vol. 8, 1902, p. 454, pl. 2, figs. 2a-2c; Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 164, pl. 13, figs. 2a-2c.

Five specimens in Matthew's collection are called types of this species: A, B, C, D, and E. Of these the last is the original of Matthew's figures; hence it is regarded as the type of the species. On comparison it is found that D agrees exactly with the type E, while A and B agree much better; indeed, it is believed they agree in every

respect with *B. vigilans* mut. *obesa* Matthew, which is regarded as a good species and not a mere mutation. Finally, specimen C represents a distinguishable variety of *B. vigilans* s. s. described on a following page as *B. vigilans concentrica*.

The most striking feature common to all three specimens is the sharp definition and unusual prominence of the ocular tubercle. It is a more conspicuous feature even than would appear from the figure. In other respects the illustrations are fairly accurate for the typical form (specimens D and E). Compared with other species of the genus, the outline of this is peculiar in being rather narrowly rounded posteriorly and in the cardinal and ventral portions being more nearly parallel than in any of the others known. The anterior edge is somewhat thickened, the posterior end of the hinge projects as a thick blunt spine, and the surface punctation is rather fine. The affinities of the species as here restricted are with *B. scrutator* and *B. benepuncta*, differing from both in the narrow posterior part in having a post-cardinal spine, a more prominent ocular tubercle, and finer surface punctae. As to the supposed mutation *obesa*, it is regarded as a very different species with relations to *B. cambrica* and *B. spectator*, rather than *B. vigilans*.

Occurrence.—Lower Cambrian (Upper Etcheminian division E2b, E3d, E3e): Dugald Brook, Cape Breton, Nova Scotia. Walcott localities 10p, 13m'', 13n''.

Cat. No. 50525, U.S.N.M.

BRADORIA VIGILANS CONCENTRICA, new variety

Plate 3, Figures 18, 19

Bradoria vigilans MATTHEW (part), Bull. Nat. Hist. Soc. New Brunswick, No. 18, 1899, p. 205; Canadian Record Sci. vol. 8, 1902, p. 454; Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 164.

This new variety is represented by well-preserved specimens in the Walcott collection and by one of the types (C) of Matthew's *Bradoria vigilans*. Variety *concentrica* differs from the typical form of *B. vigilans* (1) in the more concentric arrangement of the surface punctae, a rugulose aspect being observable toward the edges, and (2) in the broader, thicker, straighter, and more nearly vertical trend of the anterior margin. The new variety suggests affinities to species of the *B. rugulosa* section, the approximation being toward *B. ovalis* rather than any of the other species of that section.

Occurrence.—Lower Cambrian (Upper Etcheminian, division E3d): Dugald Brook, Cape Breton, Nova Scotia. (Walcott locality 13n''.)

Cotypes.—Cat. No. 50527 U.S.N.M.

BRADORIA BENEPUNCTA (Matthew)

Plate 1, Figure 16; Plate 2, Figures 6, 7; Plate 3, Figure 7

Bradoria scrutator MATTHEW (part), Bull. Nat. Hist. Soc. New Brunswick, No. 18, 1899, p. 204; Canadian Record Sci., vol. 8, 1902, p. 451; Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 163.

Bradorona observator var. *benepuncta* MATTHEW, Canadian Record Sci., vol. 8, 1902, p. 449, pl. 1, fig. 16; Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 161, pl. 12, fig. 16.

This form is not a mere mutation of *Bradorona observator* (= *Bradoria perspicator*), but should be ranked as a distinct species, differing sufficiently in outline to be recognized without much difficulty. It has longer and more oblique valves, the greatest ventral prominence being farther back, causing the antero-ventral outline to be straighter, longer and more oblique, and the posterior edge more nearly vertical. The punctation is very fine (about as in *B. perspicator* s. s.), but the nodes on the cardinal slope, mentioned in the original description, are not structural but due to sand grains.

Bradoria benepuncta, as the species may be called, is closely allied to *B. scrutator*, but in the latter species the punctation is coarser, the ocular tubercle nearer the anterior extremity, and the posterior outline not exactly the same. A closer ally, probably is *Bradoria subquadrata*, new name (= *Bradorona spectator acuta* Matthew), in which the punctation is similarly fine and the general outline not greatly different. While somewhat smaller, perhaps the only differences of any consequence are (1) that the ocular tubercle is nearer the anterior extremity in *B. subquadrata*, and (2) the outline, because of the sharper ventral angles and the more broadly truncated anterior end, more quadrangular.

Occurrence.—Lower Cambrian (Etcheminian, E1b-E1d, E2a, E2b, E3d; and Hanfordian, C1b3): Boundary Brook Escasonie, Cape Breton, Nova Scotia, and Hanford Brook, New Brunswick. Walcott localities 2i, 2k, 10p, 13d, 13n'', 13n', 13t, Dugald Brook, Cape Breton, Nova Scotia.

Plesiotypes.—Cat. No. 50542, U.S.N.M. (13n'').

BRADORIA BENEPUNCTA SPISSA, new variety

Plate 2, Figures 8, 9

Several specimens in the Walcott collection indicate either a closely allied species or a good variety of *B. benepuncta*. Both forms appear to occur in nearly the same beds. The new one has a finer surface network and the posterior half of the outline more broadly rounded. Other, perhaps inconsequential, differences were noted on close comparison.

Occurrence.—Lower Cambrian (Etcheminian, E1b, E2b): Dugald Brook, Cape Breton. (Walcott locality 10p.) Occurs also at localities 10p'' and 13t.

Cotypes.—Cat. No. 50544, U.S.N.M.

BRADORIA MEDIALIS, new species

Plate 3, Figure 5

This is another apparently undescribed species. Its relations seem to be near *B. benepuncta* and the new variety of *B. robusta*—in fact, its systematic position is thought to be between these two species.

Occurrence.—Lower Cambrian (Etcheminian, E2b); Dugald Brook, Cape Breton, Nova Scotia. (Walcott loc. 10p.)

Holotype.—Cat. No. 50548 U.S.N.M.

BRADORIA ACUTA (Matthew)

Plate 1, Figure 25; Plate 3, Figures 1, 2

Schmidtella acuta MATTHEW, Bull. Nat. Hist. Soc. New Brunswick, No. 18, 1899, p. 206, pl. 4, figs. 4a–4c; Canadian Record Sci., vol. 8, 1902, p. 465, pl. 11, figs. 12a–12c; Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 173, pl. 13, figs. 12a–12c.

Bradorona observator mut. *ligata* MATTHEW (part) Canadian Record Sci., vol. 8, 1902, p. 451; Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 162.

Not *Bradorona spectator acuta* Matthew (= *Bradoria subquadrata*, new name).

The types of *Schmidtella acuta* and type specimen B of *Bradorona observator ligata* are unquestionably the same. As mentioned in notes on *Bradoria scrutator*, the figured type of the supposed mutation *ligata* (specimen A), is clearly distinct from specimen B, but can not be distinguished from typical specimens of *B. scrutator*. Concerning the types of *S. acuta*, there can be no doubt that Matthew mistook the nearly vertical and almost straight posterior margin for the dorsal edge. In two of his types (A and B), one or both of which were used by him in illustrating the supposed *Schmidtella*, the small yet sharply defined ocular tubercle is clearly visible near the narrow anterior extremity. This feature, as well as the very finely and closely punctate surface and a narrow marginal rim, is better preserved in specimens belonging to the Walcott collection. Basing our judgment upon all these specimens, we are satisfied that the species is a good *Bradoria*, related on the one side to *B. scrutator* and *B. benepuncta*, and on the other to *B. subquadrata* (= *B. spectator acuta* Matthew). At present it is the smallest species of the genus and is distinguished further by its narrow anterior end and decidedly triangular outline and from most others by its distinct though narrow marginal rim.

Occurrence.—Lower Cambrian (Etcheminian, E1b–E1d, E2b, E2c, E3a, E3c–Ecf): Dugald Brook, Cape Breton. Walcott localities 10p, 13l, 13m'', 13n'.

Plesiotypes.—Cat. No. 50537, U.S.N.M.

BRADORIA SUBQUADRATA, new name

Plate 3, Figure 3

Bradorona spectator var. *acuta* MATTHEW (part), Canadian Record Sci., vol. 8, 1902, p. 447; Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 159.

Not *Schmidtella?* *acuta* Matthew (= *Bradoria acuta*).

Of the three specimens labeled types of *Bradorona spectator* var. *acuta*, one (specimen C) is a poor mold of the exterior of some undeterminable yet undoubtedly distinct species of *Bradoria* from that represented by the other two specimens. The latter, marked "A" and "B", seem to be opposite valves of one species, A, however, being of an individual nearly twice the size of B. The "variety," as represented by these two specimens, is certainly not the same species as *B. spectator*, the outline of the valves being very different in the two forms. In *B. spectator* the ventral border is neatly rounded and its most prominent point but little behind the center of the valves. The posterior and anterior borders also are distinctly rounded. The outline of the types of the "variety," on the contrary, are so decidedly quadrangular that curvature is scarcely suggested. Indeed, the so-called variety is much more closely allied in general aspect and structure to *Bradoria acuta* (*Schmidtella?* *acuta*), differing only in the broader truncation of the anterior end in the somewhat sharper angulation of the postventral extremity, and in the very slightly coarser pattern of its surface punctation. Judging from specimen A the carapace grew to larger size than has been observed in *B. acuta* (1899). The ocular tubercle is not well preserved, but doubtless was smaller and rather inconspicuous.

As the name *acuta* is preoccupied in the genus *Bradoria* the new name, *Bradoria subquadrata*, is suggested for this species.

Occurrence.—Lower Cambrian (Lower Etcheminian, E1d): Dugald Brook and Boundary Brook, Escasonie, Cape Breton.

BRADORIA ELONGATA, new species

Plate 3, Figure 8

This new species is related to *Bradoria acuta* and *B. benepuncta* but is readily distinguished by its greater length, for which reason the name *B. elongata* is suggested. In this respect this new species differs from all other species of the genus now known.

Occurrence.—Lower Cambrian (Etcheminian, E2b, E3b): Dugald Brook, Cape Breton. (Walcott locality 10q., 13n''.)

Holotype.—Cat. No. 50541, U.S.N.M. (10q.)

BRADORIA OVALIS (Matthew)

Plate 1, Figure 18; Plate 3, Figure 6

Indiana ovalis MATTHEW, Canadian Record Sci., vol. 8, 1902, p. 461, pl. 2, figs. 8a-8c.

Indiana ovalis and mutation *prima* MATTHEW, Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 170, pl. 13, figs. 8a-8c.

This fine species is represented by a single specimen in the set of Matthew's types before us.² Another much better preserved example is in the Walcott collection from Dugald Brook, the type locality. The shell of Matthew's type is mostly exfoliated and its outline somewhat obscured and injured in cleaning, but after a very careful comparison of the two specimens, we have not the least doubt of their specific identity. Judging more especially from the Walcott specimen, the species approximates *B. robusta* and *B. rugulosa* in surface ornament, and the former also somewhat in general form. It is, however, proportionately longer, has a narrower anterior end and rather more uniformly rounded posterior margin. In shape *B. ovalis* is not greatly different from *B. scrutator*, *B. benepuncta*, and *B. obesa*, but it is distinguished from the first two by its rounded posterior, from the latter by its more elongate form and narrower anterior, and from all three by the concentric arrangement and somewhat rugulose character of its surface markings.

The ocular node is well developed; hence the species has no very close relations to the species to which Matthew's genus *Indiana* is restricted.

Occurrence.—Lower Cambrian (Etcheminian, E1e, E2b, E3e): Dugald Brook, Cape Breton, Nova Scotia. Mutation *prima*, Coldbrookian, Dugald Brook.

Plesiotype.—Cat. No. 81378, U.S.N.M. (10p).

BRADORIA RUGULOSA Matthew, emended

Plate 1, Figure 17

Bradoria rugulosa MATTHEW, Bull. Nat. Hist. Soc. New Brunswick, No. 18, 1899, p. 205, pl. 3, figs. 3a-3d; Canadian Record Sci., vol. 8, 1902, p. 456, pl. 11, figs. 3a-3d; Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 166, pl. 13, figs. 3a-3d.

Bradoria observator mut. *laevis* MATTHEW, Canadian Record Sci., vol. 8, 1902, p. 450; Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 161.

The three specimens upon which the so-called "mutation" *laevis* is founded are of the same form, but this form is not clearly related

² There are two specimens so labeled, but the second is undoubtedly distinct from the figured type, having coarser surface punctae and a general aspect suggesting identity with *B. scrutator* or *B. vigilans*.

to, and certainly not a mere mutation of, *B. observator*. It is a more oblique carapace with the most prominent point on the ventral outline farther behind the middle and the anterior end proportionally narrower than in that species. The surface marking also is quite different, consisting of fine pitting, or rather punctation, in *B. observator*, while in mutation *laevis* it consists of confluent granules, separating rows of minute punctae, arranged in a concentric manner. This type of marking characterizes *B. rugulosa*, and when the types of this species were more closely scrutinized it was found that they agreed not only in surface ornament but in shape as well. Matthew's figure of *B. rugulosa* would never suggest such a relationship, but it is a fact, nevertheless, the original of the figure being imperfect and partly covered by matrix on its posterior side. The other specimens of *B. rugulosa* in the type lot clearly prove the contention that this species is the same as the "mutation" *laevis*.

Occurrence.—Lower Cambrian (Upper Etcheminian, E1b, E1c, E2a, E2c, E3e): Dugald Brook, Cape Breton (mut. *laevis* = E1b).

Cat. Nos. 50514, 50515, U.S.N.M. (13d'', 13t).

BRADORIA ROBUSTA (Matthew)

Plate 1, Figures 1-5; Plate 2, Figures 1-4

- Aparchites* (?) *robustus* MATTHEW, Trans. Royal Soc. Canada, ser. 2, vol. 4, sect. 4, 1898, p. 132, pl. 1, figs. 4a-c.
- Indiana?* *robusta* MATTHEW, Canadian Record Sci., vol. 8, 1902, p. 461.
- Leperditia*?? *rugosa* MATTHEW, Canadian Record Sci., vol. 8, 1902, p. 443, pl. 1, figs. 7a-c; Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 155, pl. 12, figs. 7a-c.
- Bradorona perspicator* mut. *maxima* MATTHEW, Canadian Record Sci., vol. 8, 1902, p. 445, pl. 1, figs. 9a, 9b; Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 157, pl. 12, figs. 9a, 9b.
- Bradorona perspicator* mut. *major* MATTHEW, Canadian Record Sci., vol. 8, 1902, p. 446, pl. 1, figs. 10a, 10b; Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 158, pl. 12, figs. 10a, 10b.
- Bradorona perspicator* mut. *magna* MATTHEW, Canadian Record Sci., vol. 8, 1902, p. 446, pl. 1, figs. 11a, 11b; Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 158, pl. 12, figs. 11a, 11b.

Bradoria robusta, or, as Matthew called it, *Aparchites* and later *Indiana robusta*, is represented by three specimens, A, B, and C, from division C1, B, Long Island, Kennebecasis River. A is a decorticated cast of the interior of a left valve, B and C are imperfect molds of the exterior of a left and a right valve, respectively. Though the material is not in condition admitting of a positive determination of the point, it is believed that A, which is regarded as the type of the species, is distinct from B and C and that the latter two molds are of a more elongate species, probably a form later called *Indiana pyriformis*, which seems to be a large variety of *Indiana secunda*.

As based on specimen A, we find that *Bradoria robusta* is the same species to which Matthew subsequently applied the names *Leperditia?? rugosa*, *Bradorona perspicator* mut. *maxima*, *B. perspicator* mut. *major*, and *B. perspicator* mut. *magna*. It is the largest of all the known St. Lawrence Atlantic province Bradoriidae.

Careful comparison and further cleaning of the types of the three supposed mutations of *B. perspicator* (*maxima*, *major*, and *magna*) prove to our full satisfaction that they are three examples of a single indivisible form or "mutation," and this a species that we think is readily enough distinguished from the types of *B. perspicator*. This other species, for which the earliest name *robusta* is selected, differs in being more oblique, more convex, and larger. Its normal form is a composite of Figures 3 and 4 of Plate 1 on which the three "mutations" are figured. The original of Figure 5 (mutation *magna*) was injured on the cardinal edge. Restoring this and removing matrix covering the post ventral edge, we have a nearly exact correspondence with Figure 4.

Another form figured on this plate, namely, *Leperditia?? rugosa*, almost certainly belongs to the same species as *B. robusta*. The original unfortunately is in bad condition, having evidently been crushed and distorted by pressure. This, like several other specimens of these peculiar Cambrian branchiopods, indicates by the crinkling of its shell that the same was much more pliable than any ostracod shell known to us; but there is so little doubt as to its original shape that we can not hesitate in referring it to the same species as *B. robusta*. The crushing of the type of *L. rugosa*, as is indicated by the accumulation of wrinkles, was especially effective along the ventral border, the consequent shortening of this thus giving the different outline as figured by Matthew. The name *robusta* is selected for the reason that in 1898 Matthew applied this name, under *Aparchites*, to another example of the same species.

A number of excellent specimens in the Walcott collection clearly proves that the surface ornamentation of *B. robusta* is essentially of the same concentrically rugulose pattern found in *B. rugulosa*. This, however, is a larger species and differs further in the obtuse angulation of the central part of the anterior edge, and the straightness of the outline between this angle and the anterior extremity of the hinge. Good specimens also exhibit a spine at the posterior extremity of the hinge not observed in *B. rugulosa*.

Occurrence.—Lower Cambrian (Hanfordian C1b): Kennebecasis River (*Aparchites robustus*); Upper Etcheminian, Indian Brook (*L. rugosa*); Lower Etcheminian, Dugald Brook (*B. perspicator magna* and *B. perspicator maxima*); Upper Etcheminian, Dugald Brook, Nova Scotia (*B. perspicator major*).

In the Etcheminian the species occur in divisions E1b-E1d, E2a, E2b, E3d-E3f. Walcott localities 10p, 10p', 13d, 13d', 13n', 13n'', 13t, 13t'', 10p.

Plesiotypes.—Cat. Nos. 50517 (13g), 50518 (13d), U.S.N.M.

BRADORIA ROBUSTA LONGULA, new variety

Plate 2, Figure 5

A specimen in the Walcott collection from Dugald Brook indicates a species that, while readily distinguishable, is yet manifestly closely allied to *B. robusta*. The principal difference is the greater length of its cardinal margin; but as this peculiarity imparts a strikingly different outline to the valves, it is thought to be of importance. Unfortunately we have seen but a single specimen, and therefore can not say how constant these peculiarities may be. The surface markings are of the concentric pattern found in *B. robusta* and *B. rugulosa*.

Occurrence.—Lower Cambrian (Lower Etcheminian, div. E1b): Dugald Brook, Cape Breton, Nova Scotia (locality 13t).

Holotype.—Cat. No. 81379, U.S.N.M.

BRADORIA TONTOENSIS, new species

Plate 3, Figure 20

Of this species but a single specimen, a right valve, has been discovered. It is, however, very readily distinguished from all the other species of the group so far known by its outline and particularly by the obsolescence of the ocular node. This latter feature casts some doubt upon the generic reference; but as all the other features of the valve seem to be in harmony with the genus, the species may provisionally at least be fittingly placed here. Compared with other species of *Bradoria* we note considerable resemblance to such forms as *B. robusta* and *B. ovalis*. From both, however, it is at once distinguished by its more sharply defined cardinal angle and by the relatively greater height. From *B. robusta* it is further distinguished by the more nearly vertical anterior edge and the greater fullness of the posterior ventral part of the outline.

Occurrence.—Middle Cambrian (Bright Angel shale): Near mouth of Bass Canyon, Grand Canyon of the Colorado, Ariz.

Holotype.—Cat. No. 81377, U.S.N.M.

BRADORIA PERSPICATOR (Matthew) s. s.

Plate 1, Figures 6-9; Plate 3, Figure 12

Bradorona perspicator MATTHEW, Canadian Record Sci., vol. 8, 1902, p. 444, pl. 1, figs. 8a-8d; Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 156, pl. 12, figs. 8a-8d.

Bradorona observator MATTHEW, s. s. Canadian Record Sci., vol. 8, 1902, p. 448, pl. 1, figs. 15a-15c; Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 160, pl. 12, figs. 15a-15c.

There are four specimens marked as types of *Bradorona perspicator* all doubtless conspecific. One, marked "A," the original of Matthew's figures 8a, 8b, and 8c, is the best preserved and therefore considered as the real type of the species. The original figures are accurate except in representing the ventral outline more sharply rounded than it is in the specimen and in giving the valve greater thickness (one-third more) in the edge views than we think it possesses. The ocular tubercle also is rather nearer the hinge than shown in the figure. *Bradorona observator*, s. s., is regarded as conspecific, and *B. spectator* a closely allied species, differing chiefly in having a somewhat coarser surface network.

In the Matthew's collection, seven specimens are called types of *Bradorona observator*. All of these seem to be merely young examples of *Bradoria perspicator*, and it is important to note that the types of the two so-called species are all from the same locality and bed (Lower Etcheminian, E1D, Boundary Brook, Nova Scotia). The surface pitting is fine and the same in both sets of types, and the outline and contour of valves precisely the same except that in the smaller examples (*B. observator* s. s.) the postcardinal angle or spine is less developed than in the larger examples (*B. perspicator* s. s.). It is a singular fact that the types of the three species, *spectator*, *perspicator*, and *observator*, are much nearer each other than any of the three is to the so-called mutations of the last.

Matthew's figure of *B. observator* (like that of *B. perspicator*) is too narrowly rounded at the middle of the ventral edge; i. e., this part of the outline is more produced in the illustration than in the original.

Occurrence.—Lower Cambrian (Lower Etcheminian, division E1d, E2a, E2b): Boundary Brook, Escasonie, Cape Breton. Walcott locality 10p, 13d'', Dugald Brook, Nova Scotia.

Plesiotype.—Cat. No. 50532, U.S.N.M. (13d'').

BRADORIA SPECTATOR (Matthew) s. s.

Plate 1, Figure 19

Bradorona spectator MATTHEW, Canadian Rec. Sci., vol. 8, 1902, p. 447, pl. 1, figs. 12a-d; Geol. Surv. Canada, Rep. Cambrian Rocks, Cape Breton, 1903, p. 158, pl. 12, figs. 12a-d.

The types of this form indicate such close relations to *B. perspicator* s. s. that we feel justified in doubting they can be successfully distinguished as species. Both forms are Lower Etcheminian and found at the same locality, namely, Boundary Brook. The selected types of the two differ slightly in size of surface punctation and a little in shape, *B. spectator* being somewhat less triangular and proportionately

higher. Matthew's figure is too full in the postventral region, and the postcardinal angle, which should be more, as in Figure 6, is not sufficiently brought out.

In the Matthew collection eight specimens are labeled types of *B. spectator*. Only two of these have the coarser network regarded as the principal feature distinguishing the species from its nearest allies. All of the other six specimens, when in condition to determine at all, are the same as the types of *B. perspicator* and its synonym *B. observator* s. s.

Occurrence.—Lower Cambrian (Etcheminian, division E1c, E1d, E2l, E3e); Boundary Brook, Nova Scotia. Walcott locality, 10p. (Dugald Brook).

Cat. No. 50530 U.S.N.M. (10p).

BRADORIA SPECTATOR SPINOSA (Matthew)

Plate 1, Figures 20, 21

Bradorona spectator mut. *spinosa* MATTHEW, Canadian Rec. Sci., vol. 8, 1902, p. 448, pl. 1, figs. 13 a, b; Geol. Surv. Canada, Rep. Cambrian Rocks, Cape Breton, 1903, p. 159, pl. 12, figs. 13 a, b.

Bradorona spectator mut. *aequata* MATTHEW, Canadian Rec. Sci., vol. 8, 1902, p. 448, pl. 1, figs. 14 a, b; Geol. Surv. Canada, Rep. Cambrian Rocks, Cape Breton, 1903, p. 160, pl. 12, figs. 14 a, b.

Mutations *spinosa* and *aequata* are identical, the peculiarities supposed to distinguish them being greatly exaggerated in the figures and disappearing after a little cleaning of the specimens. The somewhat greater development of the postcardinal spine distinguishes the variety from the typical form of *B. spectator* and the closely allied *B. perspicator*.

Occurrence.—Lower Cambrian (Lower Etcheminian, E1e, *spinosa*, and E3d, *aequata*): Dugald Brook, Cape Breton.

BRADORIA CURTA, new species

Plate 3, Figure 10

This interesting new species represents an extreme in the genus in the length of its hinge line and the corresponding apparently greater width of the valve.

The ocular node is little developed, but otherwise the right valve upon which the species is founded has all the characters of *Bradoria*. In spite of its narrow hinge line the outline of the valve shows the five unequal sides characteristic of the genus.

Occurrence.—Lower Cambrian (Etcheminian, division E3a): Dugald Brook, Cape Breton, Nova Scotia (*loc. 13l'*).

Holotype.—Cat. No. 50547, U.S.N.M.

BRADORIA OBESA (Matthew)

Plate 1, Figure 27; Plate 3, Figure 13

Bradoria vigilans MATTHEW (part), Bull. Nat. Hist. Soc., New Brunswick, No. 18, 1899, p. 205; Canadian Record Sci., vol. 8, 1902, p. 454; Geol. Surv. Canada, Rept. Cambrian Rocks, Cape Breton, 1903, p. 164.

Bradoria vigilans mut. *obesa* MATTHEW, Canadian Rec. Sci., vol. 8, 1902, p. 455.

A single specimen only is marked as representing this supposed mutation of *Bradoria vigilans*. As stated above in the remarks on that species, we find that three of the specimens labeled *B. vigilans* are really in every respect like the type of the mutation *obesa*. Further, we find these four specimens so constant in their characters and so readily distinguished by their shorter and more obese form, and even finer surface punctae, from the figured typical specimens of *B. vigilans* that we can not hesitate to regard them as specifically distinct. The outline of the valves of *B. obesa* is considerably like that of *B. perspicator* and *B. spectator*, differing only in being a trifle more obtuse in the ventral and anterior parts, but the ocular tubercle is so much better defined and the carapace so much thicker that there should be little difficulty in distinguishing them. In the last feature the species is allied to *B. cambrica*, in which, however, the ocular tubercle is much less developed.

Occurrence.—Lower Cambrian (Etcheminian, division E1b–E1d, E2b, E3d): Dugald Brook, Cape Breton, Nova Scotia. Walcott locality 13n'', 10p'':)

Cat. Nos. 50528, 50529, U.S.N.M.

"SCHMIDTELLA? PERVETUS" Matthew

Plate 1, Figure 26

Schmidtella (?) *pervetus* MATTHEW, Bull. Nat. Hist. Soc., New Brunswick, No. 18, 1899, p. 206, pl. 4, figs. 3a–c; Canadian Rec. Sci., vol. 8, 1902, p. 464, pl. 2, figs. 11a–c; Geol. Surv. Canada, Rep. Cambrian Rocks, Cape Breton, 1903, p. 172, pl. 13, figs. 11a–c.

As noted under the discussion of *Bradoria concinna*, the type of *Schmidtella* (?) *pervetus* Matthew was so poorly preserved as to be indeterminable, but the type of *S. pervetus* mutation *concinna* proved to be a valid species of *Bradoria*. Under the circumstances it seems best to recognize *Bradoria concinna* and to drop the name *Schmidtella?* *pervetus*.

Occurrence.—Lower Cambrian (Upper Etcheminian, division E3e): Dugald Brook, Cape Breton, Nova Scotia.

BRADORIA CONCINNA (Matthew)

Plate 3, Figure 9

Schmidtella(?) pervetus mut. *concinna* MATTHEW, Canadian Record Sci., vol. 8, 1902, p. 464; Geol. Surv. Canada, Rept. Cambrian Rocks, Cape Breton, 1903, p. 173.

The "mutation" *concinna* was founded on a single specimen. It was in a good state of preservation, but required cleaning to bring out all of its characters. As now developed, the ocular tubercle is shown to be very slightly developed, and this feature serves very well in distinguishing the species from the otherwise closely similar *Bradoria spectator spinosa*. The ocular tubercle is not perfectly preserved nor is the antero-cardinal angle complete in the type, but both are satisfactorily shown in a specimen belonging to the Walcott collections. Comparing the species as known by these two specimens with *Bradoria spinosa*, *B. concinna* is smaller, slightly longer transversely, its dorsal angles less produced, the dorsal slope a trifle fuller, and the surface ornament perhaps a shade coarser than in *B. spinosa*.

The type of *Schmidtella? pervetus* being too poorly preserved to be determinable, it is suggested to raise the supposed variety *concinna* to the rank of a species and to drop the name *pervetus*.

Occurrence.—Lower Cambrian (Lower Etcheminian, division Elc, Eld): Boundary Brook, Escasonie, Nova Scotia. (Walcott locality 13t'') Dugald Brook, Nova Scotia.

Cat. No. 50510 U.S.N.M. (13t'').

BRADORIA CAMBRICA (Matthew)

Plate 1, Figure 10; Plate 3, Figures 14, 15

Schmidtella cambrica MATTHEW, Trans. New York Acad. Sci., vol. 14, 1895, p. 137, pl. 7, figs. 10a, 10b.

In its outline the type of this species, is much like *Bradoria spectator* and even more like *B. obesa*. It is smaller, however, and its ocular node less developed. From the former it differs considerably in having the central part of the valves much more elevated. *B. obesa* approaches it in this respect, but *B. cambrica* is a trifle shorter and has coarser surface punctation. *B. concinna* is longer transversely.

Matthew's type of *S. cambrica*, when figured and described by him, did not exhibit an ocular tubercle, but it shows clearly enough now since the obscuring matrix has been removed.

Occurrence.—Lower Cambrian (Hanfordian, division Clb3): Hanford Brook, St. Martins, New Brunswick. (Walcott locality 2i.)

Plesiotype.—Cat. No. 50533, U.S.N.M. (2i.)

BRADORIA MINOR (Matthew)

Plate 1, Figure 22

Leperditia(?) minor MATTHEW, Trans. New York Acad. Sci., vol. 14, 1895, p. 138, pl. 8, figs. 4a, 4b.

A single specimen represents this species. It is partly exfoliated, and the preservation of the posterior edge is not wholly satisfactory, but enough is retained to prove the systematic position of the species to be within the genus *Bradoria*. It agrees with *B. scrutator* in surface pitting and in the position and degree of development of the ocular tubercle, but differs in the outline of the valves, these being shorter and relatively broader anteriorly. Further, the contour of the valve (a left valve) differs in being less uniformly convex, the surface of the valve being obscurely conical and sloping in every direction from a subcentral apex. In its general aspect, *B. minor* resembles also *B. rugulosa* and *B. obesa*, and it is thought to be nearer the last than to any other known.

Occurrence.—Lower Cambrian. (Hanfordian, division Clb3): Hanford Brook, New Brunswick.

BRADORIA? STEADI (Matthew)

Plate 1, Figure 23

Leperditia steadi MATTHEW, Trans. Royal Soc. Canada, vol. 7, sect. 4, 1890, p. 160, pl. 7, figs. 13a–13c; Trans. New York Acad. Sci., vol. 14, 1895, p. 137, pl. 8, figs. 7a–7c.

No specimens of this species are present in the collection, but judging from the figures and description only it differs from *Bradoria minor* in little save size, being at least twice the width of that form. While it may be seriously questioned whether this is a valid specific difference, it is impossible to determine the point without specimens. Besides, *Leperditia steadi* may prove to be something very different, though that it should belong to *Leperditia* seems extremely improbable. In the meantime it is thought safer to remove it to *Bradoria*.

Occurrence.—Lower Cambrian (Hanfordian, division Clb): Hanford Brook, New Brunswick.

BRADORIA "PRIMAEVA" (Matthew)

Plate 1, Figure 29

Beyrichia (?) primaeva MATTHEW, Trans. Royal Soc. Canada, ser. 2, vol. 4, sect. 4, 1898, p. 133, pl. 1, figs. 2a–2c.

The specimen marked as the type of this species is an imperfect mold of the exfoliated exterior of a left valve. It is evidently a species of *Bradoria*, but with the material in hand it would not be safe to suggest alliances. As it is impossible to identify the species, the name should be dropped.

Occurrence.—Lower Cambrian (Hanfordian, division Clb2): Hanford Brook, New Brunswick.

BRADORIA? ORNATA Matthew

Plate 1, Figure 24

Bradoria(?) ornata MATTHEW, Canadian Record Sci., vol. 8, 1902, p. 456, pl. 2, figs. 4a-4c; Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 166, pl. 13, figs. 4a-4c.

This also is represented by a single example too poor to be definitely placed. No part of the margin is complete, and so far as preserved there is nothing to distinguish it from *B. scrutator* or *B. oculata*. The type being unidentifiable, the name should be dropped.

Occurrence.—Lower Cambrian (Lower Etcheminian, division Elc): Dugald Brook, Escasonie, Cape Breton.

BRADORIA? AURORA (Matthew)

Plate 1, Figure 28

Primitia aurora MATTHEW, Trans. Royal Soc. Canada, vol. 11, sec. 4, 1894, p. 98, pl. 17, figs. 5a-c; Trans. New York Acad. Sci., vol. 14, 1895, p. 136, pl. 8, figs. 1a-c.

Bradoria(?) aurora MATTHEW, Bull. Nat. Hist. Soc. New Brunswick No. 18, 1899, p. 204 (gen. ref.); Canadian Rec. Sci., vol. 8, 1902, p. 452.

Original description.—Suboval, elongate, nearly straight along the back, somewhat narrow towards the anterior end, flattened along the hinge line, and turned towards the ventral margin. There is a short broad vertical furrow at the anterior edge of the hinge line, whose length is about one-third of the whole length of the valve.

Sculpture.—This consists of closely set pits, just visible to the naked eye.

Size.—Length about 4 mm; width about 2 mm; height of valve about 1¼ mm. Matthew's type was not present in his collection when studied by us, so that we have to leave the status of the species uncertain.

Occurrence.—Lower Cambrian (Hanfordian, Clb1): Hanford Brook, New Brunswick.

BRADORIA FENNICUS (Wiman)

Plate 3, Figure 17

Aparchites fennicus WIMAN, Bull. Geol. Inst. Upsala, vol. 6, pt. 1, 1902, p. 46, pl. 3, fig. 51.

The illustration of *Aparchites fennicus* Wiman as reproduced on Plate 3 certainly shows the relationship of the species to American forms like *Bradoria scrutator* and *B. benepuncta*.

Occurrence.—Cambrian (gray quartzitic sandstone): Åland, Sweden.

BRADORIA NITIDA (Wiman)

Plate 3, Figure 16

Bradorona nitida WIMAN, Bull. Geol. Inst. Upsala, vol. 6, pt. 1, 1902, p. 48, pl. 1, figs. 34, 36, 37.

The illustration of the type of *Bradorona nitida* Wiman, reproduced on Plate 3, indicates that it belongs to *Bradoria* and is not unlike certain of the American species.

Occurrence.—Cambrian sandstone: Island of Åland, Sweden.

BRADORIA HICKSII (Jones)

Plate 3, Figure 4

Leperditia hicksii JONES, Quart. Journ. Geol. Soc. London, vol. 28, 1872, p. 183, pl. 5, fig. 16; Ann. Mag. Nat. Hist., ser. 5, vol. 8, 1881, p. 346, pl. 20, fig. 6.

As figured this species seems to be allied most closely to *B. vigilans*, differing from it chiefly in the slight elevation of its ocular tubercle. It constitutes, indeed, a very inconspicuous feature in this species, while in *B. vigilans* it is a very prominent one. The proportion of height and length is different, the height being relatively greater. Finally the posterior outline is much more broadly rounded.

Occurrence.—Middle Cambrian (Menevian): St. Davids, Wales.

Genus WALCOTTELLA, new genus

Carapace bivalved, subovate, 3 to 7 mm. in length, hinge straight, rather long. Valves moderately convex, usually with a more or less prominent, conical eminence situated in the median third of the length and occasionally one or two much less conspicuous nodes near the antero-dorsal angle. Edges of valves thin, bordered, gaping anteriorly and posteriorly. Test phosphatic, thin, pliable, closely punctate exteriorly.

Genotype.—*Walcottella apicalis*, new species.

This genus is named after the late Dr. Charles D. Walcott, to whose acumen and diligence science is indebted for the splendid collection of Cambrian fossils in the United States National Museum. All of the species so far known of this genus were procured by him from the late Middle Cambrian Bright Angel shale in the Grand Canyon of the Colorado in Arizona.

The thirteen species brought together under the above generic designation, though exhibiting a considerable range of variation, seem yet to constitute a natural association. The most variable and at the same time the most obvious of the generic characters is the submedian eminence. In *W. apicalis* and *W. concentrica* it is situated very near the center of the valves. In *W. breviscula*, according to the adopted orientation of the valves, this eminence is well behind the middle, but in all of the remaining species it tends to move

anteriorly. Except *W. ventrosa*, in which it is situated relatively farther forward than in the others, the variability in position with respect to the middle of the valves would seem to be largely accounted for by variation in the proportionate lengths of the anterior and posterior halves. Regarding the eminence as an approximately fixed point, and taking into account the matter of size of valves, the proportional distance from its apex to the anterior edge is much less variable than is the distance to the posterior edge. Hence, when the valve is elongate, as in *W. oblonga*, *W. longula*, *W. limatula*, and *W. scitula*, the apex is more or less anterior of the middle. On the contrary, when the valve is relatively short, the apex is near the middle or behind that point.

A rather disconcerting fact is notable in *W. leperditoides*, *W. nitida* and *W. obsoleta*. In these species, namely, the median eminence is barely distinguishable or quite obsolete. After close study, however, it has seemed indisputable that the first two are still close allies of *W. pulchella* and *W. apicalis*, while the last can not be far removed from *W. oblonga*.

Respecting the morphological significance of the surface nodes of *Walcottella*, the small elevation frequently observable in the antero-cardinal angle is thought to be the homologue of the similarly placed node in *Bradoria*, and of the "eye tubercle" in *Leperditia* and *Isochilina*. The larger median eminence doubtless corresponds to the "muscle spot" of the Ordovician and Silurian Leperditidae and not to the more ventrally situated but otherwise similar spine found in the group of *Isochilina* typified by *I. armata*. The relations suggested are further strengthened by the striking similarity in general aspect presented by *W. leperditoides* and *W. nitida* to average examples of *Leperditia*. Were it not for the obvious differences in the substance and other features of their respective shells, it would be difficult to point out convincing reasons for classifying these two Cambrian species under *Walcottella* and not *Leperditia*.

Compared with other Cambrian genera of bivalved Crustacea, it is at once distinguished from *Bradoria* by the median eminence. Comparing certain species of each genus, essential agreement in general outline is noted, but the more typical species of *Bradoria* exhibit obtuse angulations in the anterior and posterior parts of their outlines—sometimes also in the ventral part—that do not occur in *Walcottella*. Matthew's genus *Indiana*, as herein defined, is probably also related, but the total absence of surface nodes in that group of species is a sufficiently obvious distinction to render confusion between them unlikely. It might occur only in comparing forms like *Walcottella leperditoides* and the associated *Indiana faba*. Another useful, though perhaps not very important, difference is observed in studying the outer surface of the shell. In *Walcottella*,

namely, the surface is always distinctly and closely pitted. In *Indiana*, on the contrary, the surface is always at least smooth and generally polished, the punctae, which are usually present, being very small and distant.

The relations of *Walcottella* to *Aluta* Matthew, as redefined by the writers, are probably much less than may appear on first thought. *Aluta* often has a small node in the anterior half of the valves that may suggest the median tubercle of a *Walcottella* like *W. limatula*. On further study the node in the former is recognized as representing the "ocular node" and not the "muscle spot." The test of *Aluta* also is quite different, being thinner, smooth, and almost membranous. Finally, the general shape is different, the valves having a more decided retral swing and the antero-cardinal angle being sharper and the most prominent part of the anterior margin. In fact, *Aluta* is believed to represent another family and to be much more closely allied to the new genus *Dielymella* than to *Walcottella*.

WALCOTTELLA APICALIS, new species

Plate 4, Figures 1, 2

Description.—Carapace subovate, slightly oblique, widest posteriorly; length and height respectively about as 4 is to 3 or 5 to 4; hinge straight, rather long, about three-fourths of the total length; antero-cardinal angle sharp, 100° to 110° ; postcardinal angle distinct but much wider, about 130° ; excepting the cardinal edge and small parts just beneath its extremities, the outline forms a nearly regular elliptic curve. Surface of valves depressed conical, sloping at first sharply and then more gradually, though not uniformly, in all directions from the apex of the strong, centrally situated conical eminence; slope to the cardinal edge more concave than to the ventral margin. A wide, flattened border, very distinct on the right valve but scarcely defined on the left, extends around the free edges. Two low ridges usually distinguishable in the space between the median tubercle and the antero-cardinal angle. The anterior of these two ridges is the longer and may be recognizable halfway down the anterior side. The inner swelling, which probably embraces the "eye spot," is flanked on either side by an ill-defined depression. Surface of shell closely punctate, or rather reticulate, the pattern, as to size and arrangement of punctae about as in *W. breviscula*. (See pl. 4, fig. 5.) A tendency to concentric arrangement of the punctae is occasionally observable in the middle part of surface.

Dimensions of an average example: Length 5 mm.; greatest height, 4 mm.; thickness between apices of median nodes estimated at nearly 5 mm.

In its outline this species resembles *W. breviuscula* and *W. leperditoides*, but is distinguished at once by the much greater strength and prominence of its median tubercle.

Occurrence.—Middle Cambrian, sandstone beds in the Bright Angel shale just above the massive lower bed, near mouth of Bass Canyon, Kwagunt Valley, and Chuar Valley, Grand Canyon, Ariz.

Cotypes.—Cat. Nos. 56477, 56478, U.S.N.M.

WALCOTTELLA CONCENTRICA, new species

Plate 4, Figures 3, 4

Description.—Carapace comparatively small, broadly subovate, the outline, except for the short and not sharply defined hinge line, approximately circular. As a rule one side, thought to be posterior, is somewhat narrower and longer than the other. Surface of valves somewhat depressed convex to the base of the but slightly eccentric, strong conical tubercle; or the whole surface may slope away from the apex with little change in angle. The specimens present no indication of smaller anterior nodes, nor is there any satisfactory evidence of a flattened border. Surface of shell rather coarsely punctate, the punctae elongate and so arranged that they suggest interrupted concentric wrinkles.

Dimensions of an average carapace: Length 3.0 mm.; greatest height 2.5 mm.; thickness between apices of median tubercles about 2.5 mm.

Remarks.—This species, besides being smaller than the others is readily distinguished by its nearly circular valves and the concentrically arranged and wrinklelike pitting of the surface. When exfoliated it is not so easily separated from the young of *W. apicalis*, to which it is doubtless also closely allied. The collection contains eight specimens.

Occurrence.—Bright Angel shale, Bass Canyon and Chuar Valley Grand Canyon of the Colorado, Ariz. Associated with the preceding.

Cotypes.—Cat. Nos. 56479, 56480, U.S.N.M.

WALCOTTELLA BREVIUSCULA, new species

Plate 4, Figures 5, 6

Description.—Carapace of medium size, subovate; hinge line two-thirds the greatest length, straight, the anterior extremity sharply angular, the posterior angle more obtuse; ends nearly equal, the anterior slightly the narrower and less curved in the upper part of its outline. Valves moderately convex, the slope of the rounded surface clearly distinguished from the base of the conical median tubercle. This, though a prominent feature, is smaller than in *W. apicalis* and *W. concentrica*, and is situated well behind the center, provided the smaller end is really the anterior. Ocular and other nodes indistin-

guishable. Surface of shell distinctly puncto-reticulate, the pattern as coarse as in any and obviously coarser than in most of the other species. No well-defined flattened marginal border.

Dimensions of the best specimen, a left valve: Greatest length, 4.5 mm.; greatest height, 3.5 mm.; thickness (one valve), about 1.4 mm.

Remarks.—In deciding that the smaller of the two ends is the anterior in this species, the judgment of the writers has been based chiefly on the fact that in nearly all bivalved crustacea having a straight hinge, the antero-cardinal angle is sharper than the posterior; and when the outline is oblique with respect to the hinge line, the "swing" is backward. Relying on these criteria, the median tubercle is situated behind the middle of the valves, an arrangement that serves well in distinguishing the species from all the others now referred to the genus. Aside from this peculiarity, *W. breviscula* resembles *W. pulchella*, the principal other differences being that the ends are less unequal in width and the surface ornament coarser in the present species. In *W. apicalis* the apex of the median tubercle is slightly in front of the middle, low ridges are recognizable in the antero-cardinal region, and the slope of the surface of the valves from the apex to the margins more suggestive of the uniform grade of a depressed cone.

Occurrence.—Bright Angel shale, Bass Canyon, Grand Canyon of the Colorado, Ariz. Two specimens only found. Associated with the preceding.

Cotypes.—Cat. No. 56481, U.S.N.M.

WALCOTTELLA SCITULA, new species

Plate 4, Figure 7

Description.—Carapace somewhat elongate, obliquely subovate, with long, straight hinge, beginning rather abruptly at the anterior end but passing much more gradually into the semicircular curve of the posterior margin; anterior end considerably narrower than the posterior. Surface of valves rather strongly convex, rising from the margins with first a convex, then a nearly uniform depressed conical slope to the apex. The summit is located a little in front of the middle, does not rise abruptly in profile, but is marked by a smooth space. Ventral part of margin not preserved, but that remaining on the ends seems not to have been provided with a flattened border. Ocular node not developed. Surface of shell puncto-reticulate, the pattern in the median area tending to a concentric arrangement of the punctae about the smooth apical spot.

Dimensions of the unique type specimen: Greatest length, 4.7 mm.; greatest height, about 3.0 mm.; greatest thickness, left valve only, about 1.2 mm.

Remarks.—The ventral margin of the type specimen is imperfect. As restored in our photographic illustration, it resembles *W. pulchella*, but is still too elongate for that species. The antero-cardinal angle also is different, while the median tubercle of the latter is more prominent and pointed and situated farther anterior. Finally, *W. pulchella* has smaller and closer punctae. *W. scitula* probably also is related to *W. apicalis*, but the median tubercle of the latter is so much stronger that confusion between them is very unlikely. Imperfect specimens of *W. oblonga* might be confused, but complete examples are readily distinguished by their oblong, equal-ended shape.

Occurrence.—A single left valve only was found associated with the preceding species in the Bright Angel shale at Bass Canyon, Grand Canyon of the Colorado, Ariz.

Holotype.—Cat. No. 56482, U.S.N.M.

WALCOTTELLA PULCHELLA, new species

Plate 4, Figures 11, 12

Description.—Carapace egg-shaped, decidedly narrower in front than behind, greatest height and greatest length, respectively, as 2 is to 3; hinge rather short, only five-eighths of the greatest length, the two extremities obtusely angular and more nearly equal than usual; valves gaping distinctly at the ends and probably also a little along the ventral margin; edges of valves with a thin, wirelike rim. Surface of valves rather strongly convex; flattening along free margins inconspicuous; median tubercle small but prominent, pointed, its apex located about one-tenth of the length of the carapace anterior to the middle; eye node apparently not distinguishable. Surface of shell very finely puncto-reticulate.

Dimensions of type specimen: Length 4.0 mm., greatest height 2.7 mm.; greatest thickness, between apices of median tubercles, 2.3 mm.

Remarks.—This neat species resembles *W. ventrosa* and *W. limatula* but is easily recognized by its simple border, greater convexity, and different outline. It is really more closely allied to *W. leperditoides*, *W. scitula*, and *W. apicalis*. From all of these it is distinguished by the finer pattern of its surface network. Compared further with each, the first is larger and without a well-defined median tubercle, the second is more elongate and has a less pointed node, while the third has a larger tubercle and conical rather than convex valves.

Occurrence.—The figured specimen only has been seen. This was broken out of a block of the same bed of the sandstone in the Bright Angel shale from which most of the species of this genus were procured by Walcott at his locality in Bass Canyon, Grand Canyon of the Colorado, Ariz.

Holotype.—Cat. No. 56483, U.S.N.M.

WALCOTTELLA LEPERDITOIDES, new species

Plate 4, Figure 8

Description.—Carapace leperditoid in shape, the outline with respect to the long and straight hinge being somewhat oblique, the cardinal angles, especially the anterior, well defined, the upper part of the end margins straight, and the ventral half of the outline semiovate. The surface of the valves rises to a subcentral, broadly rounded apex, the slope toward the ends nearly uniform and toward the dorsal and ventral edges slightly convex. A slight flattening, barely visible even in favorable lighting, occurs along the free margins. Excepting a considerable space about the apex, the surface of the shell is distinctly puncto-reticulate.

Dimensions of a good left valve: Greatest length 6.2 mm., greatest height 4.2 mm., greatest thickness about 1.9 mm.

Remarks.—Were it not for the white, phosphatic shell of this fossil, it might be difficult to remove the impression of close relationship to *Leperditia* that is at once suggested by its general aspect. This impression, however, is quickly invalidated by the shell structure, which is exactly the same as in the other species of *Walcottella* and contrasts strongly in color, probable chemical composition, and minute surface markings, with that prevailing among the true Leperditidae from their first appearance in the Beekmantown to the last at the close of the Silurian. That it is not a *Leperditia* is further indicated by the free edges which surely never overlapped in the ventral part. In every essential feature, except the median tubercle, which is practically obsolete, *W. leperditoides* agrees with *W. pulchella*, and that species is most certainly not a close ally of the much later Leperditidae. That the latter were derived out of *Walcottella* is thought highly probable, but the differences between the known forms of the two types are at least of family importance.

Compared with other species of *Walcottella*, the obsolescence of the median tubercle serves readily in distinguishing *W. leperditoides* from those simulating it in other respects.

Occurrence.—Same as the preceding.

Holotype.—Cat. No. 56484, U.S.N.M.

WALCOTTELLA NITIDA, new species

Plate 4, Figures 9, 10

Description.—Carapace broadly subovate, hinge long, straight, the cardinal angles clearly defined, the anterior one especially sharp; ends not very unequal, the posterior slightly the wider and more uniformly curved at the margin than the anterior, the front outline slightly concave in the upper third; ventral half of outline a nearly regular though broad semiellipse. The right valve figured on Plate 4 is the only

specimen seen. It is clean cut but largely exfoliated and retains small patches of the delicate white exterior layer of the shell only along the margins. Except along the anterior side there is no evidence of a flattened border, but on the internal cast an impressed line follows the ventral edge and marks off a narrow band. The surface is rather strongly convex, reaching its greatest elevation a short distance in advance of the middle of the valve in a low, conical, radially marked eminence representing the median tubercle of the other species of the genus. Between this elevation and the antero-dorsal angle is a smaller but more sharply defined node regarded as the ocular tubercle. Just in front of this and extending downward parallel with the anterior edge, a shallow furrow. Surface of shell puncto-reticulate, the pattern and size of punctae about as in *W. breviscula*, figured on the same plate. The punctae extend through the outer into the inner layer of the shell.

Dimensions of the type specimen, a right valve: Length 4.8 mm., greatest height (across the posterior half) 3.2 mm., greatest thickness about 1.3 mm.

Remarks.—The general aspect of this valve is highly suggestive of certain species of *Isochilina*, an Ordovician and Silurian genus of Leperditiiidae. However, for essentially the same reasons mentioned in discussing the resemblance of *W. leperditoides* to *Leperditia*, the evidence is convincing that in this case also the resemblance is not based on true affinity. An ocular node and the shallow anterior furrow are both present in *W. apicalis*, but the median tubercle is so much stronger in that species that, while their generic alliance seems assured, their specific relations can not be very intimate. Both *W. pulchella* and *W. leperditoides* probably are nearer allies, but neither of these has an ocular tubercle.

Occurrence.—Sandstone bed in Bright Angel shale, Bass Canyon, Grand Canyon of the Colorado, Ariz.

Holotype.—Cat. No. 56485, U.S.N.M.

WALCOTTELLA OBLONGA, new species

Plate 5, Figure 8

Description.—A right valve only has been observed, and this is imperfect in the posterior and ventral half of the outline. So far as preserved and interpreted, the carapace is oblong or subcylindrical with rounded ends, the hinge line straight, long, the anterior angle obtuse but well defined, the posterior angle more indefinite, the ventral side gently convex and approximately parallel to the hinge. Surface rather strongly convex, the median tubercle not very conspicuous and situated its diameter in advance of the middle of the valve. The eye node is barely distinguishable and the puncto-

reticulate ornament of the shell somewhat coarser than that of *W. limatula* and a grade finer than in *W. scitula* and *W. breviscula*.

Dimensions of the type specimen: Greatest length 3.8 mm., greatest preserved height 2.0 mm., probable height of perfect valve, about 2.3 mm., thickness of single valve about 0.9 mm.

Remarks.—Despite the imperfections of the unique example upon which this species is based, its preserved characteristics seemed sufficiently peculiar and indicative of the complete form to justify its description. If correctly understood, the species is allied to *W. scitula* and *W. obsoleta*, being in fact an intermediate form. Better specimens of all three of these species are necessary before their relations may be accurately determined.

Occurrence.—Sandstone in Bright Angel shale, Bass Canyon, Grand Canyon of the Colorado, Ariz.

Holotype.—Cat. No. 56486, U.S.N.M.

WALCOTTELLA OBSOLETA, new species

Plate 4, Figure 13

Description.—Only a single specimen, thought to be a right valve, is known of this species. The curvature of the dorsal and ventral slopes is unusually abrupt. This fact, together with apparent imperfections of both the posterior and anterior thirds of the cardinal edge, suggests that the specimen has suffered compression, causing it to appear more elongate than originally. This distortion probably affected the posterior half more than the anterior. It is believed that the normal form should be higher, possibly intermediate between what it is now and the restored figure of *W. scitula* on the same plate. Bearing this in mind, the species may be briefly characterized as follows: Carapace rather elongate, oblong to subrhomboidal, the height four-ninths to possibly three-fifths of the length; ends subequal, hinge straight, cardinal angles not very sharply defined, ventral margin gently convex. Surface strongly convex, the point of greatest prominence beneath and considerably in front of the middle; tubercles quite obsolete. Surface of shell with the usual punctate ornament; color yellowish white.

Dimensions of the specimen described: Greatest length, 5.5 mm., greatest height, 3.0 mm.; thickness of one valve about 1.3 mm.

Remarks.—The unique example on which this species is founded has precisely the same kind of shell as all of the other species referred to the genus. It can not, however, be claimed as a typical member of the genus, the entire obsolescence of the median tubercle and the unusual length being such obvious departures from the average forms of *Walcottella*, that its classification is necessarily attended with some doubt. Still in the matter of elongation, the present species barely exceeds *W. oblonga*, which doubtless is its closest known relative,

while in the matter of the reduction of the median tubercle, it is no worse off than *W. leperditoides*.

Occurrence.—Same as *W. apicalis*, *W. leperditoides*, etc., Bright Angel shale, Grand Canyon, Ariz.

Holotype.—Cat. No. 56487, U.S.N.M.

WALCOTTELLA LIMATULA, new species

Plate 5, Figures 1-3

Description.—Carapace subovate, wide posteriorly, narrow anteriorly, with a long straight hinge line and obtusely angular cardinal extremities; anterior margin most prominent in the upper third beneath which it recedes rapidly in the lower two-thirds; ventral margin rather strongly convex, its posterior third, together with the whole of the posterior outline to the extremity of the hinge, forming a uniform circular curve. Valves only moderately convex, the curvature of the surface, disregarding the nodes, almost uniform from end to end; free margins, when perfect, with a distinct, flattened border. When this border is broken away, as in Figure 1, on Plate 5, the form appears more elongate than normal. Main tubercle located about one-fifth of the length in advance, and slightly above the middle, strong, conical, conspicuously elevated above the general surface of the valve. Midway between this tubercle and the anterior extremity of the hinge is a much smaller, ocular node. Surface of shell very finely puncto-reticulate, the pattern smaller than in any of the preceding species except *W. pulchella*.

Dimensions of the type specimen: Greatest length 5.0 mm.; greatest height 3.2 mm., greatest thickness (between apices of main tubercles) 1.8 mm.

Remarks.—This seems to be the commonest of the species of the genus collected by Walcott at his locality in Bass Canyon, nine or ten specimens being confidently referred to it. While the species appears to be fairly constant, it may yet be observed that in some of the specimens the ventral part of the outline is less convex, the anterior extremity less narrowly curved, and the main tubercle a little stronger than in Figure 2 on Plate 5. Such a specimen is represented by the original of Figure 1 on the same plate. Possibly they constitute a recognizable variety.

Compared with other species of the genus, *W. limatula* is easily distinguished by the shape of its valves. Of those approaching it most in this respect, *W. ventrosa* will be found to be shorter and to have the ends more nearly equal in size and curvature of outline. *W. subtruncata* and *W. longula* also are closely allied but differ so obviously from *W. limatula* in the truncation and greater width of their anterior extremities, that comparison between them is not likely to occur.

Occurrence.—Bright Angel Shale, Grand Canyon, Ariz.

Cotypes.—Cat. No. 56488, U.S.N.M.

WALCOTTELLA VENTROSA, new species

Plate 5, Figures 4, 5

Description.—Carapace broadly elliptical, truncated by the hinge line; ends subequal, curving regularly into the convex ventral margin; cardinal angles obtuse, almost rounded. Surface of valves gently convex, the free edges narrowly rimmed. Main tubercle rather small but very sharply elevated, located almost in the middle of the antero-dorsal fourth. Midway between this and the cardinal angle a minute ocular node is barely distinguishable. Surface of shell minutely puncto-reticulate.

Dimensions of figured specimen, a right valve: Length 3.1 mm., height 2.2 mm., thickness about 1.0 mm.

Remarks.—This pretty species doubtless is closely allied to *W. limatula*. The principal difference lies in the outline which is more uniformly curved, the ends consequently being nearly equal, whereas in that species the posterior is the wider and the curvature of the margins of the ends quite different. *W. ventrosa* seems also to be a smaller species.

Occurrence.—Associated with *W. limatula* and most of the other species of the genus here described, in the Bright Angel shale, Bass Canyon, Grand Canyon, Ariz.

Holotype.—Cat. No. 56489, U.S.N.M.

WALCOTTELLA SUBTRUNCATA, new species

Plate 5, Figure 6

Description.—Carapace subquadrate, hinge straight, ventral edge moderately convex, ends, especially the anterior, obliquely truncated so that the greatest length lies well beneath the mid height; postero-ventral part of outline less abruptly curved than the corresponding part on the anterior side. Surface moderately convex, the flattened border narrow but well defined, the median tubercle of moderate size but conspicuously elevated, located one fifth the length in front of the middle of valve; two comparatively obscure nodes occur between the main tubercle and the antero-cardinal angle. Surface of shell minutely reticulated.

Dimensions of the type specimen: Greatest length 4.1 mm., length of hinge 3.2 mm., greatest height 3.0 mm., thickness of single (right) valve about 1.6 mm.

Remarks.—*W. subtruncata* is easily distinguished from all the preceding species of the genus by its quadrate form. The following *W. longula* alone resembles it in this respect.

Occurrence.—Same as *W. ventrosa*, *W. limatula*, and other species collected from the Bright Angel Shale at Bass Canyon, Grand Canyon, Ariz.

Holotype.—Cat. No. 56490, U.S.N.M.

WALCOTTELLA LONGULA, new species

Plate 5, Figure 7

This species is so much like the preceding *W. subtruncata* that a detailed description is unnecessary. The types of the two species agree in every essential respect except that *W. longula* is relatively more elongate, and that the tubercle is situated above instead of on the level of the middle of the valve. None of the other species of the genus is sufficiently like it to require comparisons.

Dimensions: Greatest length 5.0 mm., length of hinge 3.6 mm., greatest height 3.0 mm., thickness about 1.2 mm.

Occurrence.—Same as *W. subtruncata*.

Holotype.—Cat. No. 56491, U.S.N.M.

BEYRICHONIDAE, new family

Carapace bivalved with valves apparently fitting close together all around the edges, leaving no gap. Surface of valves with a depressed anterodorsal region bordered by variously arranged ridges or nodes. Shell structure black, calcareo-corneous.

Genus BEYRICHONA Matthew

Beryrichona MATTHEW, Trans. Royal Soc. Canada, vol. 3, sect. 4, 1886, pp. 64, 65.—MILLER, North Amer. Geol. and Pal., 1889, p. 535.—MATTHEW, Trans. New York Acad. Sci., vol. 14, 1895, p. 133.—JONES, Geol. Mag., dec. 4, vol. 9, 1902, p. 402.

Escasona MATTHEW, Canadian Rec. Sci., vol. 8, 1902, p. 457.—JONES, Geol. Mag., dec. 4, vol. 9, 1902, p. 402.—MATTHEW, Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 167. (Genotype: *E. rutellum* Matthew.)

The essential characters of the genus as founded on *Beryrichona papilio* and *B. tineae* are (1) the subtriangular outline of the valves, and (2) a broad, undefined depression in the dorsal slope. This depression is limited in front by a short, nodelike ridge paralleling and just within the upper third of the anterior border, and on the posterior side by a thinner and more angular ridge starting at the hinge near its posterior extremity and curving slightly forward to its terminus about the middle of each valve. The central part of the depressed space is more or less convex, the swelling being most pronounced and best defined in those species in which the relative height of the valves is least (as *B. triceps*). In species like *B. ovata*, and *B. rutellum*, in which the height reaches the opposite extreme, the mesial swelling is entirely obsolete. In the most typical species, a low ridge, growing obsolete posteriorly, begins at the antero-cardinal node and forms an irregular swelling along the cardinal edge. Usually a very narrow flattened border is developed along the free margins of the valves. Length of valves in various species 3 to 5 mm.

The genus as now known to us embraces four or five typical species and three or four varieties of these probably deserving separate names. Besides these we refer here the two recognizable species of *Escasona* Matthew, which we regard as congeneric.

Matthew referred four species to his proposed genus *Escasona*. One of these, *E. ovata*, he had previously described as a *Beyrichona*. The type of the proposed genus is *E. rutellum*. Both of these species differ from the more typical species of *Beyrichona* chiefly, if not solely, in the contraction of their horizontal dimensions and in the modification of the dorsal nodes and mesial depression incident to this shortening of the valves. In our opinion, *E. rutellum* probably and *B. ovata* certainly stand at one end, and *B. triceps* at the opposite extreme of the development of a single generic type of which *Beyrichona tineae* represents the typical or average expression.

The types of *Escasona ingens* and *E. vetus* are so imperfect that it is thought impossible to ever recognize other specimens of the species with certainty. It would be to the advantage of science, therefore, to drop these names, and with them *Escasona*, unless more complete collections should prove the advisability of retaining the name for *E. rutellum*.

BEYRICHONA PAPILIO Matthew

Plate 6, Figure 11; Plate 7, Figures 5-7

Beyrichona papilio MATTHEW, Trans. Royal Soc. Canada, vol. 3, sect. 4, 1886, p. 65, pl. 6, figs. 20, 20a, 20b; Trans. New York Acad. Sci., vol. 14, 1895, p. 134, pl. 7, figs. 4a-4c.

Beyrichona triangula MATTHEW (part), Trans. New York Acad. Sci., vol. 14, 1895, p. 135, pl. 7, fig. 5.

This, the genotype, is founded on a single but good specimen showing two valves opened so that they lie in nearly the same plane. The ventral angle is prominent, acute, the posterior edge abruptly truncated, very slightly curved in outline and disposed at nearly a right angle to the hinge line. The nodes are well developed, the posterior one sharply ridged, differing thus from all the other species.

As will be noted presently, two of the types of *B. triangula* (pl. 7, figs. 6, 7) are of this species. Judging from the Walcott collection, the species is not common.

Occurrence.—Lower Cambrian (Hanfordian, division C1b2-C1b4): Hanford Brook, New Brunswick.

Plesiotype.—Cat. No. 50501, U.S.N.M. (10c. 2i).

BEYRICHONA TINEA Matthew

Plate 6, Figures 1, 2, 5-7; Plate 7, Figure 4

Beyrichona tineae MATTHEW, Trans. Royal Soc. Canada, vol. 3, sect. 4, 1886, p. 66, pl. 6, figs. 21, 21a, 21b; Trans. Royal Soc. Canada, vol. 11, sect. 4, 1894, p. 97; Trans. New York Acad. Sci., vol. 14, 1895, p. 134, pl. 7, figs. 6a-6c.

This is one of the more abundant species of this genus, and in its typical form is readily distinguished from *B. papilio* by the rounding of its ventral margin, its more erect—that is, less oblique—habit, and less angular posterior ridge. The short anterior and posterior dorsal ridges are well developed, and as compared with *B. planata* the posterior one is much better defined than usual in that variety or closely allied species. The five specimens in the Matthew collection marked types are all of the same form. Matthew's main figure of the species is accurate so far as outline is concerned, but is imperfect in representing the posterior ridge too narrow. The small oblique lines in the dorsal depression also are somewhat misleading.

Occurrence.—Lower Cambrian (Hanfordian, division C1b2–C1b4): Hanford Brook, New Brunswick.

Plesiotype.—Cat. No. 50549, U.S.N.M.

BEYRICHONA TINEA TRIANGULA (Matthew)

Plate 6, Figures 8–10; Plate 7, Figures 8, 9

Beyrichona triangula MATTHEW (part), Trans. New York Acad. Sci., vol. 14, 1895, p. 135, pl. 7, fig. 5 (see also *B. papilio*).

The three types of this form indicate two species. The specimen marked "A" represents a rather common variety of *B. tineae* in which the ventral portion is somewhat produced and hence more sharply rounded. The anterior edge also is blunter. Typical examples of this variety are readily distinguished, but in the Walcott collection there are so many intermediate specimens that we do not feel justified in according a higher rank to the form than that of a variety or mutation of *B. tineae*.

The other two specimens, marked "B" and "C," are unquestionable examples of *B. papilio*. The figure given by Matthew of *B. triangula* is manifestly a composite of the characters of two distinct species. Specimen A supplied the dorsal half, B and C the ventral part. In A the ventral extremity was obscured by adhering rock. When this was removed, the belief that this specimen, if not identical with *B. tineae*, was at least more closely allied to that species than to *B. papilio*, became strengthened to conviction, for it proved in every respect identical with a form that we had distinguished as a variety of *B. tineae*, and for which we propose to adopt Matthew's name.

Occurrence.—Lower Cambrian (Hanfordian-div. C1b3): Hanford Brook, New Brunswick.

Plesiotypes.—Cat. No. 50550, U.S.N.M. (*loc.* 2').

BEYRICHONA TINEA PLANATA (Matthew)

Plate 6, Figures, 3, 4; Plate 7, Figures 1-3

Beyrichona planata MATTHEW, Trans. New York Acad. Sci., vol. 14, 1895, p. 134, pl. 7, fig. 7.

This is represented in the Matthew collection by four specimens, three exactly alike, and one marked "B" proportionally longer on the hinge line, this difference causing the posterior edge to range something like 80° to the hinge line. In the other specimens, which bear the usual characters of the species or variety, this angle is very near 90° . Bearing this difference in mind, it appears that specimen B, which is also the largest and best preserved of the four, is the original of Matthew's Figure 7, on Plate 7, the specimen and figure agreeing exactly in the posterior half. The anterior half, however, shows differences, the figure being especially inaccurate in representing the antero-ventral part of the outline as much more convex than we find it in the specimen. His description says that the border is narrower but we failed to notice any difference in this respect when compared with *B. tineae*.

Concerning the relations of *B. planata* to *B. tineae*, the types of the two alone left no doubt as to their being very close. With the abundant material in the Walcott collection, the case became complicated by the finding of other slightly varying forms, all pointing, like *B. planata* to *B. tineae* as the central type of a variable species.

Variety C: Considering specimen B as the real type of the variety *planata*, the other three specimens, A, C, and D, would represent a second variety differing chiefly and probably solely in the more vertical disposition of the posterior edge. Both differ from *B. tineae* s. s. in the greater width of the cardinal portion of the slope from the summit of the anterior ridge to the edge of the valve; in other words, the anterior extremity of the carapace extends farther beyond the anterior node than in *B. tineae*. The greater width of this slope lends greater conspicuity to a low, generally undefined ridge that traverses it vertically. The corresponding rib is more obscurely indicated on the more abrupt anterior slope in *B. tineae*. As a rule the posterior node or ridge is less definitely developed in these varieties than in *B. tineae* but the difference is not constant.

Variety D: Another variety is represented by numerous but not very good examples in which the posterior margin is vertical as in the second variety above, but the anterior slope is abrupt as in *B. tineae*, while the postventral angle is sharply rounded as in the variety *triangula*. From the latter, as also from *B. tineae* s. s., it differs in its right-angled form, and in the comparative obsolescence of the posterior and median nodes.

Occurrence.—Lower Cambrian (Hanfordian, division C1b1–C1b3): Hanford Brook, New Brunswick.

Plesiotypes.—Cat. No. 50491, U.S.N.M.

BEYRICHONA ROTUNDATA Matthew

Plate 6, Figure 12; Plate 7, Figures 11, 12

Beyrichona rotundata MATTHEW, Trans. New York Acad. Sci., vol. 14, 1895, p. 136, pl. 7, fig. 9.

Represented in the Matthew collection by three specimens. Two of these, A and B, are alike, the third, C, not entirely clear of the matrix, seems to be a more triangular form than the other two, and probably is referable to *B. tineae*, or possibly the young of *B. tineae planata*.

Specimens A and B agree fairly well with Matthew's figure, except that the free border is scarcely so uniformly rounded as represented in the figure. As to the validity of the species, it is closely related to *tineae* and *planata*, differing from both in the lesser height of the valves and more uniformly curved ventral margin. Except that the sulci are deeper, the configuration of the dorsal half of *B. rotundata* corresponds in all essential respects with *B. tineae*, and differs, therefore, the same as that form, from *B. planata*. Possibly this form also is but a variety of *B. tineae*, but if the peculiarities shown in the types are fairly constant, it will be best to class it as closely allied but specifically distinct.

Occurrence.—Lower Cambrian (Hanfordian, division C1b2, C1b3): Hanford Brook, New Brunswick.

Plesiotype.—Cat. No. 50500 U.S.N.M.

BEYRICHONA TRICEPS (Matthew)

Plate 6, Figures 13–15

Beyrichia triceps MATTHEW, Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 219, pl. 16, figs. 4a–4c.

Though resembling the Silurian genus of Ostracoda in general aspect, this species is no more a *Beyrichia* than are the other Bradoriidae and Beyrichonidae. The type specimens are all more or less imperfect, but between them they leave no doubt in our minds that the species belongs strictly to *Beyrichona*. In essential features it differs from the typical species solely in being relatively elongate. The nodes, especially the central one, are somewhat stronger in *B. triceps*, but this is to be expected as a natural result of the vertical shortening.

The greater the proportionate height (see *Escasona*) the less distinctly developed are the nodes.

The species, as judged from a large number of specimens in the Walcott collection, is rather variable in the relative proportions of height and length.

Occurrence.—Middle Cambrian (Johannian, division C2b): McLean Brook, near Marion Bridge; Dugald Brook; and 1.5 miles west of Marion Bridge, Cape Breton, Nova Scotia.

Plesiotypes.—Cat. No. 50502-50504, U.S.N.M. (3i, 10s, 13g).

BEYRICHONA OVATA Matthew

Plate 7, Figure 10

Beyrichona ovata MATTHEW, Trans. New York Acad. Sci., vol. 14, 1895, p. 135, pl. 7, fig. 8.

Escasona ovata MATTHEW, Canadian Rec. Sci., vol. 8, 1902, p. 458 (gen. ref.)

The original type of this species (it is accompanied by a second specimen too poorly preserved to be identified) is a *Beyrichona* with an extremely short hinge. On account of this shortening of the carapace, the median dorsal depression is very narrow, and, being deep, the central swelling observed in the more typical species is entirely obsolete. The antero-cardinal node, however, is as in *B. tineae*, while the parts in which it differs are behind this node, hence in those portions of the carapace which the variations in the more typical species of the genus show to be comparatively unstable. In short, while *B. ovata* is a well marked and good species, it is yet a *Beyrichona*. Matthew's figures are fairly accurate.

Occurrence.—Lower Cambrian (Hanfordian, division C1b2): Hanford Brook, New Brunswick.

BEYRICHONA FABAE Wiman

Plate 7, Figure 17

Beyrichona faba WIMAN, Bull. Geol. Inst. Upsala, vol. 6, pt. 1, 1902, p. 47, pl. 3, fig. 52.

Although imperfect the type specimen of *Beyrichona faba*, judging from the original illustration here reproduced closely approaches in outline certain American species such as *B. tineae planata* Matthew.

Occurrence.—Lower Cambrian, Olenellus bituminous sandstone: Limön near Gefle, Sweden.

BEYRICHONA GEVALENSIS Wiman

Plate 7, Figures 14-16

Beyrichona gevalensis WIMAN, Bull. Geol. Inst. Upsala, vol. 6, pt. 1, 1902, p. 46, pl. 1, figs. 29, 30, 35.

Wiman's figures are so similar to American species like *B. tineae* that there can be no doubt of the correct reference of this species to *Beyrichona*.

Occurrence.—Lower Cambrian, Olenellus bituminous sandstone: Biludden, Sweden.

BEYRICHONA ALTA Wiman

Plate 7, Figure 13

Beyrichona alta WIMAN, Bull. Geol. Inst. Upsala, vol. 6, pt. 1, 1902, p. 47, pl. 3, fig. 53.

The type and only specimen is an imperfect valve, but according to the figure of it published by Wiman it clearly represents an elongate species of *Beyrichona*.

Occurrence.—Lower Cambrian, Olenellus bituminous sandstone: Limön near Gefle, Sweden.

BEYRICHONA? RUTELLUM (Matthew)

Plate 1, Figure 32; Plate 3, Figure 21

Escasona rutellum MATTHEW, Canadian Rec. Sci., vol. 8, 1902, p. 458, pl. 2, figs. 5a-5c; Geol. Surv. Canada, Rept. Cambrian Rocks Cape Breton, 1903, p. 167, pl. 13, figs. 5a-5c.

Depending solely upon the original type of this species, *B. rutellum* appears to be a short hinged form in which the essential features of *Beyrichona* are recognizable only in a subdued condition; that is, they are somewhat obscurely developed. The hinge is considerably shorter than the height, the dorsal depression is smaller and less defined than usual, and the antero-dorsal node, as well as the sulcus immediately behind it, less distinctly developed. Still, all these features of *Beyrichona* are so clearly recognizable that generic separation seems undesirable. On the other hand, it is not to be denied that the surface pitting and general aspect of the valve is not greatly different from species of *Bradoria* like *B. cambrica*. Possibly with more specimens (we have seen only Matthew's original) it may be shown that the affinities of the species are really nearer *Bradoria* than *Beyrichona*. In that case *Escasona* might stand, but in no case should it include *Beyrichona ovata*, which also has an unusually short hinge.

Occurrence.—Lower Cambrian (Etcheminian, division E3f): Gillis, Indian Brook, Cape Breton, Nova Scotia.

DOUBTFUL SPECIES

ESCASONA INGENS Matthew

Plate 1, Figure 31

Escasona (?) *ingens* MATTHEW, Canadian Rec. Sci., vol. 8, 1902, p. 459, pl. 2, figs. 7a-c; Geol. Surv. Canada, Rep. Cambrian Rocks Cape Breton, 1903, p. 168, pl. 13, figs. 7a-c.

The single specimen bearing this name, hence the type, is so indefinitely preserved that it would be unsafe to venture an opinion.

Occurrence.—Lower Cambrian (Coldbrookian): Dugald Brook, Nova Scotia.

ESCASONA VETUS Matthew

Plate 1, Figure 33

Escasona(?) vetus MATTHEW, Canadian Rec. Sci., vol. 8, 1902, p. 458, pl. 2, figs. 6a, b; Geol. Surv. Canada, Rep. Cambrian Rocks Cape Breton, 1903, p. 168, pl. 13, figs. 6a, b.

The only specimen bearing this label is also too imperfect to justify description. It presents obscure resemblance to *E. rutellum*, but the pitting of its surface is of a coarser pattern. It is recommended that this name and the preceding be dropped as unrecognizable.

Occurrence.—Lower Cambrian (Lower Etcheminian, division E1d): Boundary Brook, Nova Scotia.

Genus SELLULA Wiman

Sellula WIMAN, Bull. Geol. Inst. Upsala, vol. 6, pt. 1, 1902, p. 48.

This genus is evidently related to *Beyrichona*, differing in that the surface of the valve is concave with a thin ridge along the anterior and posterior borders and the middle part of the anterior extremity is produced into an obtuse angulation. A narrow border is present along the post ventral part.

Genotype.—*Sellula fallax* Wiman.

SELLULA FALLAX Wiman

Plate 7, Figures 18, 19

Sellula fallax WIMAN, Bull. Geol. Inst. Upsala, vol. 6, pt. 1, 1902, p. 48, pl. 1, figs. 31, 32.

The characters of this the genotype and only species are given in the remarks upon the genus.

Occurrence.—Lower Cambrian, Olenellus bituminous sandstone: Biludden, Sweden.

Genus ALUTA Matthew, emended

Aluta MATTHEW, Trans. New York Acad. Sci., vol. 15, 1896, p. 198.—MILLER North Amer. Geol. and Pal., App. 2, 1897, p. 786.

Leperditia FORD (not Rouault), Amer. Journ. Sci., ser. 3, vol. 6, 1873, p. 138.—WALCOTT, Bull. No. 30, U. S. Geol. Surv., 1886, p. 146; Amer. Journ. Sci., ser. 3, vol. 34, 1887, p. 193; 10th Ann. Rep. U. S. Geol. Surv., 1890, p. 628.

Aristozoe WALCOTT (not Barrande), Amer. Journ. Sci., ser. 3, vol. 34, 1887, p. 193; 10th Ann. Rep. U. S. Geol. Surv., 1890, p. 627.

Bradoria WALCOTT (not Matthew), Proc. U. S. Nat. Mus., vol. 29, 1905, p. 99.

Description.—Carapace bivalved, 2 to 10 mm. long; valves apparently closing all around, leaving no gaps, obliquely acuminate-subovate in outline, narrow and acuminate anteriorly, broad and rounded posteriorly, straight along dorsal side; antero-dorsal angle sharp, often produced, 90° or less; posterior angle more obtuse, sometimes

rounded off; surface moderately convex, usually depressed in the antero-dorsal region; beneath this depression and generally near the lower part of the anterior edge a conspicuous though variable node or ridgelike swelling; anterior, ventral and posterior margins with a flattened border, usually widest anteriorly and sometimes excavated on the inner side. Test thin, black, corneous, pliable, smooth or punctate exteriorly.

Genotypes.—*Aluta flexilis* Matthew (original) and *Aristozoe troyensis* (Ford) Walcott.

Remarks.—The above definition aims to be a composite of the characters noted in studying the following 8 or 10 species. Together they form a reasonably compact group distinguished from all others by the form of the carapace and more especially by the node in the antero-ventral fourth. This node varies considerably in position and development, but it does not get far enough out of its normal position to suggest comparison with the ocular node in *Bradoria*. In the latter the node is strictly confined to the dorsal region of the valves; in *Aluta*, on the contrary, it must be counted a feature of the antero-ventral part.

After cleaning the original type of Matthew's *Aluta flexilis*, it was found that he had figured it upside down, and that the outline of the specimen, instead of being regularly oval, was really obliquely acuminate oval. It has a comparatively short but straight hinge line and well-defined cardinal angles. As now understood, its outline is not greatly different in essential respects from *A. stereope* (Walcott) and *A. subrotunda* (Walcott). Certainly there is not sufficient difference in their respective outlines to warrant generic separation.

Unfortunately, the type of *A. flexilis* is a specimen so crushed that it is impossible to prove that it was originally provided with a node. The specimen is thought to consist of both valves, which, fitting closely and consisting of a pliable substance, constituted a baglike carapace that collapsed when it was subjected to the pressure of the entombing sediments. The Chinese *A. fragilis* (Walcott) is founded on similarly crushed specimens. However, the irregularities of the surface of the type of *A. flexilis* probably are not altogether accidental, the elevation between the large and two smaller depressions in the anterior part of the specimen possibly corresponding to the characteristic node. Believing that the specimen on which Matthew founded his genus *Aluta* really did have such a node, and as it agrees in all other generic respects with the other species here referred to the genus, it seemed a better plan to redefine *Aluta* than to confine it to *A. flexilis* and erect a new generic group for the other more fully known species.

Considered individually the species of *Aluta* indicate rather diverse alliances. Thus the smaller forms, like the Chinese *A. woodi* and

A. bergeroni, are greatly like *Lepiditta*, the principal, or rather most striking difference being the antero-ventral node which is wanting in the latter genus. The dorsal depression which is usually present in *Aluta* likewise is absent in that genus. *A. rotundata* suggests very different affinities, namely with *Beyrichona*. In fact, in the lobation of the valves this species is so highly suggestive of that genus that the resemblance is believed to be indicative of true genetic relationship. Further, if the hinge of *A. rotundata* were longer, the post-cardinal angle narrower, and the outline less oblique, this species would probably have been referred to *Beyrichona*, as has already been suggested by Matthew,³ rather than *Aluta*. Finally, most of the species of *Aluta* recall the much larger forms comprised in the genus *Dielymella*. That genus is, of course, distinguished readily enough by its gaping valves and its evenly convex surface contours, there being no sign of either the antero-ventral node or the dorsal depression generally found in *Aluta*. Still, when the latter is absent, as in *A. troyensis*, it is difficult to escape the conviction that some genetic relation exists between the two genera. Two of the species, *A. troyensis* and *A. rotundata*, were referred by Walcott⁴ to *Aristozoe*. While presenting a general resemblance to that remarkable Silurian genus of Phyllocarida, or of Phyllopoda, there should be little doubt that these Cambrian bivalved crustaceans belong to a very distinct genus. Compared with *Aristozoe*, these differ not only in being much smaller but in the more important fact that their valves close tightly all around instead of being curved so as to gap widely at the ends. Compared further they are found to differ in the general outline of the valves, in having a dorsal depression, and in the more antero-ventral position of the node or nodes. Finally the shell differs in being thinner, more flexible, and less calcareous in composition. In the position of the nodes *Aluta* is like *Callizoe*, another Silurian genus described by Barrande; but as that genus is generally regarded as related to *Aristozoe*, there is probably no direct alliance between it and *Aluta*.

Viewed as a genus, *Aluta* can not very well be classified except as an aberrant member of the family Beyrichonidae. The type differs from *Polyphyma*, *Beyrichona*, and *Hipponicharion*, the three other more typical members of the family, in the comparative brevity of its hinge and particularly in the reduction of the postdorsal angle. The latter feature is responsible for the prevailing obliquity of its outline, in which respect *Aluta* agrees with some of the Bradoriidae.

³ Trans. New York Acad. Sci., vol. 14, 1895, p. 133.

⁴ Amer. Journ. Sci., ser. 3, vol. 34, 1887, p. 193; 10th Ann. Rep. U. S. Geol. Surv., 1890, p. 628.

ALUTA FLEXILIS Matthew

Plate 8, Figures 13, 14

Aluta flexilis MATTHEW, Trans. New York Acad. Sci., vol. 15, 1896, p. 198, pl. 15, fig. 4.

Description.—Carapace acuminate-subovate, oblique, narrow, and angular in front, wide and rounded behind; hinge rather short, anterior extremity rectangular, postdorsal angle obtuse. Surface features obscured by crushing of valves. A well-defined border beginning at the antero-dorsal angle extends downward around the anterior and ventral sides but is apparently lost on the posterior side. Greatest diameter about 4.0 mm.

Remarks.—Only a single specimen of this species is known. This is the original of Matthew's description and figure of the genus and species and is now preserved in the museum of the University of Toronto. As already mentioned, further preparation of the specimen resulted in proving that it has a straight hinge and is acuminate anteriorly instead of regularly elliptical in outline. As now understood, *A. flexilis* comes so near to certain Chinese species recently described by Walcott that it is difficult to point out satisfactory differences. Thus *A. fragilis* (*Bradoria fragilis* Walcott), which also is founded on crushed examples, differs only in being smaller and in certain minor peculiarities of its outline. Chief among the latter differences is that the hinge is longer in the Chinese species, its posterior margin being more nearly vertical than in *A. flexilis*. In *A. eris*, *A. stereope*, and *A. woodi*, three other small Chinese species of the genus published by Walcott, the posterior outline is more in accord with that of *A. flexilis*. Each of these species, however, is distinguished by slight differences in the anterior parts of their outlines. On account of the crushing of the valves of *A. flexilis*, it is not possible to say whether its surface characters were materially different or not.

Occurrence.—Middle Cambrian, Acadian division of St. John group, division C1c1, Porter's Brook, St. Martins, New Brunswick.

ALUTA BERGERONI (Walcott)

Plate 8, Figures 3, 4

Bradoria bergeroni WALCOTT, Proc. U. S. Nat. Mus. vol. 29, 1905, p. 99.

Aluta bergeroni WALCOTT, Research in China, Carnegie Institution, vol. 3, 1913, p. 225, pl. 23, fig. 10.

Description.—Carapace obliquely semielliptical, narrow and acuminate anteriorly, broadly rounded posteriorly, hinge straight, nearly as long as the length of the valve; antero-dorsal angle sharp, 80° or less; post-dorsal angle somewhat obtuse, 100° or more. Surface rather strongly convex, the most prominent point a little behind and above the middle; dorsal slope more abrupt than the ventral. Node

small but distinct, rounded, located a little nearer the hinge line than the anterior extremity; from base of node a delicate ridge extends toward the antero-dorsal angle. Dorsal depression not well defined, small, confined to the area above the node and ridge. Marginal rim clearly defined, of moderate width, thick, flattened on the inner and outer faces. Except for a few shallow scattered pits that may be accidental, the surface of the shell appears smooth under a hand lens. Under a high power of magnification it shows exceedingly minute punctae.

Dimensions: Length of valve 1.8 mm., greatest height 1.00 mm., depth about 0.5 mm.

Remarks.—The unique left valve on which this species is based is readily distinguished from all the other species referred to the genus providing its present form is normal for the species. The fact that the dorsal edge of the valve is turned strongly inward so that in a view of the posterior edge the inner line of the profile is concave instead of straight, is highly suggestive of distortion. If the present form of the valve is normal, then the concavity of the edges indicates a wide gap between the valves such as is entirely unknown in the otherwise similar species with which *A. bergeroni* is associated. If, on the contrary, it is admitted that the extraordinary incurvature of the back is due to distortion, it will be found, when the easily effected restoration of the original form has been made, that the normal outline is almost the same as in *A. eris* and *A. stereope*. With the limited material available for comparison, it is impossible to establish either of these two suppositions. Under the circumstances it would be unfair to take a more decided stand than to say that the latter interpretation is thought the more likely to accord with the facts. Further, it should be said that the normal form of *A. bergeroni* is probably more nearly like that of *A. eris* and *A. stereope* than is indicated by the figures of the three forms given on Plate 8. Finally, a second specimen, unfortunately imperfect anteriorly, agrees closely in all its remaining parts with the probable normal form of *A. bergeroni*.

Occurrence.—Middle Cambrian; compact, bluish gray, thin-bedded limestones; from shingle on gravel bar in the Lan Ho, 1 mile south of Chen Ping Hsien, southeastern Shensi, China.

Holotype.—Cat. No. 56493, U.S.N.M.

ALUTA ERIS (Walcott)

Plate 8, Figure 1

Bradoria eris WALCOTT, Proc. U. S. Nat. Mus., vol. 29, 1905, p. 100.

Aluta eris WALCOTT, Research in China, Carnegie Institution, vol. 3, 1913, p. 226, pl. 23, fig. 12.

Description.—Carapace obliquely acuminate subovate, broadly rounded posteriorly, narrowing anteriorly; hinge about three-fourths

the length of valve, straight, forming an angle of about 80° with the nearly straight anterior edge; postdorsal angle obtuse. Surface moderately convex, with an ill-defined, broad depression in front of the middle of the dorsal slope and three nodelike elevations about it. The largest and roundest of the nodes is located at the base of the depression and somewhat nearer the antero-ventral edge of the valve than the middle of the dorsal edge. A thin ridge extends from this node toward the antero-dorsal angle and about midway between the two points the specimen shows part of the base of the second node rising from the ridge. Dorsal parts of specimen imperfect but showing the remains of a third small elevation near the middle of the dorsal edge. Marginal rim sharply defined, thick and convex on the anterior side, much thinner and comparatively indistinct (perhaps imperfect) on the posterior side. Under a strong lens the surface of the test is covered with shallow punctae.

Dimensions of a right valve: Length about 2 mm., height about 1.5 mm., depth about 0.5 mm.

Remarks.—The original type and only known specimen of this species has been slightly crushed and is imperfect in its dorsal and posterior parts. Judging from what may be seen, the species appears to be closely related to the associated *A. enyo* (Walcott) and *A. woodi* (Walcott). In the former the anterior edge is more nearly vertical, and the anterior half on the whole wider. A more important difference perhaps is that *A. enyo* is without the node at the base of the dorsal depression. In *A. woodi* all three nodes are indicated, but the anterior one and the lower one are both less developed, while the thin ridge connecting them is prolonged posteriorly in a looplike extension over the central part of the valve.

Occurrence.—Middle Cambrian; compact, bluish-gray, thin-bedded limestone; from shingle on gravel bar in the Lan Ho, 1 mile south of Chen Ping Hsien, southeastern Shensi, China.

Holotype.—Cat. No. 56496, U.S.N.M.

ALUTA ENYO (Walcott)

Plate 8, Figures 5, 6

Bradoria enyo WALCOTT, Proc. U. S. Nat. Mus., vol. 29, 1905, p. 99.

Aluta enyo WALCOTT, Research in China, Carnegie Institution, vol. 3, 1913, p. 225, pl. 23, fig. 11.

Description.—Carapace quadrangular, subovate, truncated along the hinge line, broadly rounded on the posterior and ventral sides, vertical at the front edge; antero-dorsal angle sharp, about 90° ; postdorsal angle more obtuse. Surface rather tumid in the posterior two-thirds, depressed in the median part of the antero-dorsal quarter. Principal (? ocular) node small, rounded, located slightly beneath and in front of the middle of the antero-dorsal fourth. A double-

headed small elevation close to the middle of the dorsal edge. Marginal rim narrow but sharply defined and uniform in development. Surface of shell very minutely punctate, appearing smooth under an ordinary hand lens.

Dimensions of type, a left valve: Length 1.0 mm., height about 0.75 mm., depth about 0.25 mm.

Remarks.—Only a single, well preserved left valve of this species has been found. It is the smallest of all the known Cambrian bivalved Crustacea. Perhaps it is a young example. Assuming that it is mature and retains its normal characteristics, the species is readily distinguished from the preceding *A. eris* and *A. bergeroni* by its more quadrangular shape. The former species is further differentiated by having a third (antero-ventral) tubercle, while in *A. bergeroni* the antero-dorsal depression is less conspicuous, and both are represented by larger specimens than *A. enyo*. The type of *A. stereope* is similarly of small size and is thought to be its closest ally. Indeed, the most striking difference between the types of *A. enyo* and *A. stereope*, namely, certain oval depressions in the anterior half of the latter that are not seen in the former, may really be due to accidental causes.

Occurrence.—Middle Cambrian; compact, bluish gray, thin-bedded limestone; from shingle on gravel bar in the Lan Ho, 1 mile south of Chen Ping Hsien, southeastern Shensi, China.

Holotype.—Cat. No. 56497, U.S.N.M.

ALUTA STEREOPE (Walcott)

Plate 8, Figures 9, 10

Bradoria stereope WALCOTT, Proc. U. S. Nat. Mus., vol. 29, 1905, p. 101.

Aluta stereope WALCOTT, Research in China, Carnegie Institution, vol. 3, 1913, p. 226, pl. 23, fig. 14.

Description.—Carapace small, obliquely acuminate-subovate in outline, the rectangular antero-dorsal part suggesting the quadrangular; hinge straight, about three-fourths as long as the valve, terminating sharply in front, less abruptly behind; posterior and ventral sides rounded. Surface of valve rather strongly convex, rising to the greatest height near the middle. A thin ridge, beginning at the antero-dorsal angle, extends inward about half the distance to the middle of the valve, where it terminates in a small tubercle. Four dentlike depressions, arranged somewhat symmetrically with respect to the ridge, and possibly of accidental origin, occur in the antero-dorsal half of the valve. One of these lies in the triangle between the ridge and the dorsal edge, a second, large and elliptic in shape, stretches half the distance from the tubercle to the postdorsal angle. The other two depressions occupy most of the space between the lower side of the ridge and the anterior margin. Marginal rim

sharply defined, rather narrow, apparently double, with an extremely delicate accessory flange on its outer edge. Surface of shell appearing smooth and polished, minutely punctate when magnified about 15 diameters.

Dimensions of type, a right valve: Length 1.1 mm., height about 0.8 mm., depth about 0.26 mm.

Remarks.—The original type and only known specimen of this species seems in an excellent state of preservation. The only possible exception to this condition is found in the dentlike depressions of the surface. These look too much like accidental indentations of the pliable shell to be accepted unqualifiedly without the corroborative evidence of other specimens. That there is good ground for suspicion is shown by a specimen of *A. woodi* having similar indentations but still recognizable by the characteristic loop of that species. Should they prove normal structures, they would afford unusually striking criteria in the determination of the species. If, on the other hand, they could be shown to be abnormal, it would practically eliminate all differences of any consequence between *A. stereope* and *A. enyo*. However, until the validity of the differences on which the separation of the two species is based can be determined, they should be recognized as distinct.

Occurrence.—Middle Cambrian; a fine-grained, bluish-black limestone boulder believed to have come from the lower part of the Ki-sin-ling limestone, collected in river drift 1 mile south of Chon-p'ing-hien, on the Nan-kiang River, southern Shensi, China.

Holotype.—Cat. No. 56498, U.S.N.M.

ALUTA WOODI (Walcott)

Plate 8, Figures 7, 8

Bradoria woodi WALCOTT, Proc. U. S. Nat. Mus., vol. 29, 1905, p. 102.

Aluta woodi WALCOTT, Research in China, Carnegie Institution, vol. 3, 1913, p. 227, pl. 23, fig. 15.

Description.—Outline of carapace obliquely acuminate-ovate, truncated along the hinge line, rather broadly rounded behind and below, the anterior side oblique, straight or slightly concave and drawn out somewhat beaklike at the anterior extremity of the hinge; postdorsal angle rather well defined, the hinge line and upper part of posterior margin making an angle of about 120°. Marginal rim distinct, of moderate width. Surface of valves rather strongly convex in the middle and posterior parts, depressed on either side of a low, mid-dorsal elevation. The principal characteristic is a thin, curved ridge, beginning at the anterior extremity and extending obliquely backward and downward to a point considerably behind the center of the valve. Here it turns on itself and forms a loop inclosing a large median relatively depressed elliptical space. Two small nodes

occur on this ridge, one at the anterior end of the loop, the other larger and somewhat crescentic in shape, about midway between the middle of the valve and the anterior extremity of the hinge. Surface very minutely punctate under a strong lens.

Dimensions of original type, a left valve: Length 2.0 mm., height 1.25 mm., depth about 0.5 mm.

Remarks.—The specimen used by Walcott in describing this species is in an unusually good state of preservation. The outline differs somewhat from that of all other species referred to the genus, but the principal and most striking peculiarity is the long curved ridge which traverses the anterior and middle parts of the valve. A second specimen, discovered in the course of these studies, and satisfactorily identified with this species by its outline and the presence of the looped ridge, has several indentations of the surface that are entirely absent in the type specimen. These indentations are comparable with those marking the surface of *A. stereope* and being clearly abnormal in the case of *A. woodi*, strongly suggest a similar origin for the other as well.

Occurrence.—Middle Cambrian; a fine-grained, bluish-black limestone boulder believed to have come from the lower part of the Ki-sin-ling limestone, collected in river drift 1 mile south of Chon-p'ing-hien, on the Nan-kiang River, southern Shensi, China.

Holotype.—Cat. No. 56494, U.S.N.M.

ALUTA FRAGILIS (Walcott)

Plate 8, Figure 2

Bradoria fragilis WALCOTT, Proc. U. S. Nat. Mus., vol. 29, 1905, p. 100.

Aluta fragilis WALCOTT, Research in China, Carnegie Institution, vol. 3, 1913, p. 226, pl. 23, fig. 13.

Original description.—“Hinge line nearly straight, about one-fifth shorter than the width of the valve. Posterior cardinal angle obtuse, with the marginal curve long and passing into the broad curve of the lower end of the valve; anterior cardinal angle about 75°, with the anterior margin nearly straight to where it merges into broad curve of the lower part of the valve.

“Surface of the valve wrinkled to such an extent that it looks like wrinkled parchment. What may be an ocular tubercle occurs a short distance from the hinge and anterior margin. Surface minutely punctate under a strong lens.

“Width [length], 2.25 mm.; length [height], 2 mm.; depth unknown, as the flexible test has been compressed.”

Remarks.—The type of this species is so badly crushed that satisfactory comparisons with the other species can not be made. The outline even may not be exactly preserved. Assuming that it is nearly normal in the type specimen, the outline may be described as essentially like that of *A. woodi* and *A. eris*. Similarly crushed carapaces

are not uncommon in the limestone holding this and the other Chinese species of *Aluta*. They exhibit considerable variation in form, but to what extent this is attributable to distortion can not be determined. Some of them doubtless belong to one or another of the associated species, all of which are of smaller diameter than the type of *A. fragilis*. Assuming that the dimensions are fairly constant for each species, only the larger examples are provisionally referred to this species.

Compared with American species, *A. fragilis* appears to be closely allied to the genotype, *A. flexilis* Matthew. Aside from the fact that the Chinese species is only about half as large, it differs chiefly, so far as the characters are known, in having a longer hinge.

Occurrence.—Middle Cambrian limestone, found loose on a gravel bar on the Nan-kiang River, 1 mile south of Chon-p'ing-hien, southern Shensi, China. Pieces of the same limestone, found on the same gravel bar, contained *A. enyo*, *A. eris*, *A. bergeroni*, *A. stereope*, and *A. woodi*; also fragments of a trilobite suggesting *Dorypyge*.

Holotype.—Cat. No. 56495, U.S.N.M.

ALUTA TROYENSIS (Ford)

Plate 8, Figures 15-17

Leperditia troyensis FORD, Amer. Journ. Sci., ser. 3, vol. 6, 1873, p. 138.—WALCOTT, Bull. No. 30, U. S. Geol. Surv., 1886, p. 146, pl. 16, fig. 5.

Aristozoe troyensis WALCOTT, Amer. Journ. Sci., ser. 3, vol. 34, 1887, p. 193, pl. 1, fig. 8; 10th Ann. Rep. U. S. Geol. Surv., 1890, p. 628, pl. 80, figs. 2, 2a.

Description.—Carapace large for the genus, obliquely subtriangular in outline, acuminate anteriorly, rounded on the postventral side; dorsal side long, slightly arcuate; anterior angle about 65° to 70°, postdorsal angle more obtuse but well defined, about 115°. Surface only moderately convex, without distinguishable depressions, highest in the anteroventral part where it rises into a large blunt spine or conical elevation. Marginal rim wide, convex, best defined on the anterior side, where a corresponding concavity on the inner side of the shell produces a narrow but distinct marginal ridge on casts of the interior. The latter show further that the main cavity of the shell is prolonged anteriorly to the extremity of the hinge and that the dorsal edge is much thicker in its anterior half than in its posterior part. Shell comparatively thick and firm in the anterior part, but otherwise apparently as in other species of the genus.

Dimensions of a left valve: Greatest diameter 7.5 mm., greatest height 5.0 mm., thickness about 1.5 mm.

Remarks.—This species is readily distinguished from all the preceding species of the genus by its greater size, firmer shell, subtriangular form, slightly arcuate dorsum, and anteroventral node. These differences might possibly warrant generic separation, but after

careful consideration it was decided to extend the limits of *Aluta* so that it might properly receive the species. While this arrangement may not be altogether satisfactory, it is certainly a more natural position than was assigned the species by Ford, who placed it under *Leperditia*, and later by Walcott, who referred it to *Aristozoe*.

Occurrence.—Limestone in shaly slates belonging in upper part of Lower Cambrian, on ridge east of the city of Troy, N. Y.; also one-half mile west of North Greenwich, Washington County, N. Y.

Plesiotype.—Cat. No. 17447, U.S.N.M.

ALUTA PRIMORDIALIS (Linnarsson)

Plate 8, Figures 11, 12

Leperditia primordialis LINNARSSON, Kongl. Sven. Vet.-Akad. Handl., vol. 8, No. 2, 1869, p. 84, pl. 2, figs. 65, 66.

Leperditia (Isochilina), primordialis LINNARSSON, Ofvers. K. Vet.-Akad. Forhandl., vol. 26, 1869, p. 196; 1875, vol. 32, pp. 15, 18, 33, 34, 37, 45.

"*Leperditia*" *primordialis* WALLERIUS, Unders. Zonen med *Agnostus laevigatus* i Vestergotland, Lund, 1895, p. 62.—GRONWALL, Danmarks Geol. Unders., II Taekke, No. 13, 1902, p. 162.

This Swedish species is known to the authors from numerous excellent specimens which show that the species can not belong to the Leperditidae, the presence of an antero-ventrally situated node being altogether foreign to any member of that family of Ostracoda. The species agrees in the form of its carapace and especially in the position of the main tubercle, with American Cambrian species of Phyllopora here referred to *Aluta*. Though easily distinguished, the taxonomic value of the differences, so far as they can be determined is not greater than specific. The truth of this statement will be apparent when the photographic copies of Linnarsson's original figures on Plate 8 are compared with the figures of *A. troyensis* and *rotundata* on the same plate.

Compared with *A. troyensis*, *A. primordialis* is distinguished by its less acuminate, relatively blunt, anterior extremity, less produced postventral margin, by the extension of the marginal rim around the postdorsal angle, the greater convexity of the valves, and finally by having a dorsal furrow that is not present in *A. troyensis*. In some of these features the Swedish species agrees better with *A. rotundata*, but the dorsal depression is much narrower, the antero-ventral node much more prominent and not ridgelike, the convexity of the valves greater, and the general form more elongate. The length, as given by Linnarsson, is 8.0 mm., the height 5.0 mm.

Occurrence.—Middle Cambrian, Olenidskiffer of Linnarsson, at several localities in the province of Vestergotland, Sweden.

ALUTA ROTUNDATA (Walcott)

Plate 8, Figures 18, 19

Aristozoe rotundata WALCOTT, Amer. Journ. Sci., ser. 3, vol. 34, 1887, p. 193, pl. 1, fig. 9; 10th Ann. Rep. U. S. Geol. Surv., 1890, p. 627, pl. 80, fig. 3.

Original description.—"General outline of the valves subrotund, with the exception of the nearly straight hinge line; anterior end slightly narrower than the posterior; general surface rather strongly convex, marked all around, except along the hinge line, by a strong marginal groove within a rounded marginal rim; a single elongate protuberance extends from the main body of the shell upward, just within the anterior marginal groove and the hinge line, where it is most prominent, and separated from the main body of the valve by a broad sulcus extending from the hinge line down on the valve over two-fifths the distance to the ventral margin.

"The shell is thin and apparently very finely granulose [more likely punctate]."

Dimensions of the original type: Length 5.5 mm., height 4.0 mm., depth (both valves) 1.9 mm.

Remarks.—The specimen described by Walcott is the only one so far seen of this interesting species. It retains both valves, which, excepting that they are slightly displaced, are in good condition. The test is thin, black, very slightly calcareous, and apparently lamellose; hence liable to exfoliation. In composition and structure it is essentially the same as the shell of *A. troyensis*, of *Walcottella*, *Dielymella*, *Beyrichona*, and most of the other bivalved Crustacea described in this work. For this and other reasons mentioned in the remarks on the genus *Aluta*, *A. rotundata* and *A. troyensis* have been removed from *Aristozoe* and *Leperditia*, to which they have been previously referred. The close relations of *A. rotundata* to *Beyrichona* also are discussed in the generic remarks.

Viewed in its specific relations, *A. rotundata* is closely comparable only with *A. troyensis* and *A. primordialis*, though readily distinguished from both. From the former it differs in many particulars, the most striking and important of these being (1) the large depression in the antero-dorsal quarter, of which no sign is observable in that species, and (2) its rounded rather than triangular shape. It is nearer *A. primordialis*, but the outlines of the two forms are scarcely less different, while the depressions and elevations in the anterior half are so obviously different in arrangement and degree of development that it is unnecessary to point out the several disagreements.

Occurrence.—Lower Cambrian; limestones interbedded in the shaly slates on M. C. Tefft's farm, about 2 miles southeast of North Greenwich, Washington County, N. Y.

Holotype and *plesiotype.*—Cat. No. 17446, U.S.N.M.

ALUTA DOUVILLEI (Mansuy)

Plate 4, Figure 17

Bradoria douvillei MANSUY, Mem. Service Geol. l'Indo-Chine, vol. 1, 1912, p. 22, pl. 1, fig. 8.

Judging from the illustration, part of which is reproduced in Plate 4, this species belongs to *Aluta* and is related to species from China with distinct cardinal angles. The crushing of the valves so common in species of *Aluta* is also shown in Mansuy's figure.

Occurrence.—Cambrian, associated with *Redlichia chinensis*, between Yi-Léang and Ko-Pao-Tsouen, eastern Yunnan.

ALUTA HOLLII (Jones)

Plate 8, Figure 33

Beurichia hollii JONES, Geol. Mag., n. ser., dec. 2, vol. 8, 1881, p. 343, pl. 10, fig. 7.

This species is apparently based upon a small specimen of *Aluta* to which genus we now refer it. Further work is necessary before its relationship to the other species of *Aluta* can be determined.

Occurrence.—Middle Cambrian (Menevian): St. Davids, Wales.

ALUTA(?) RIMULATA, new species

Plate 5, Figure 16

This new species is based upon a complete carapace flattened in the shale, with the result that the surface nodes or ridges are crushed and not very visible. A node on the anterior third and a ridge below it are apparent in other specimens referred here, while still others show the wrinkled appearance often seen in *Aluta*. The two valves also are so similar that they probably would fit close together. The narrow but conspicuous rim along the free edges of the valves will readily distinguish the species.

Occurrence.—Middle Cambrian (Ross Lake shale member of Ptarmigan formation): 3 miles southwest of head of Lake Louise, Alberta.

Holotype.—Cat. No. 81735 U.S.N.M.

Genus EREMOS Westergaard

Eremos (Westergaard Mss.) MOBERG and SEGERBERG, Meddelande Fran Lunds Geologiska Faltklubb, ser. B., No. 2, 1906, p. 75.

Although based upon a Post-cambrian species this genus has such a resemblance to *Aluta* that an illustration of the type is included herewith.

Genotype and only species.—*Eremos bryograptorum* Westergaard.

EREMOS BRYOGRAPTORUM Westergaard

Plate 8, Figure 32

Eremos bryograptorum (Westergaard, Mss.) MOBERG and SEGERBERG, Meddelande Fran Lunds Geologiska Faltklubb, ser. B., No. 2, 1906, p. 75, pl. 3, fig. 24.

Our knowledge of the species is based upon the original illustration reproduced on Plate 8.

Occurrence.—Canadian (*Bryograptus* beds): Fogelsang, Sweden.

Genus HIPPONICHARION Matthew

Hipponicharion MATTHEW, Trans. Royal Soc. Canada, vol. 3, sec. 4, 1886, p. 64.—MILLER, North Amer. Geol. and Pal., 1889, p. 549; Trans. New York Acad. Sci., vol. 14, 1895, p. 132.

Genotype.—*Hipponicharion eos* Matthew.

Matthew describes three species of this genus, namely, *Hipponicharion eos*, *H. cavatum*, and *H. minus*. While obviously closely related, the forms are yet distinguishable. As to the genus, it is a well-marked stage in the development of these peculiar crustaceans. The family relationship to *Beyrichona* is evident enough in the general shape of the valves, in the mid-dorsal depression, and in the disposition of the surface ridges and nodes. The generic peculiarity of *Hipponicharion* lies in the greater distinctness of the lateral ridges, these extending as sharply defined elevations from the cardinal angles to a point near the middle of the ventral border. The ventral extremities of these submarginal ridges, while more or less closely approximated, still remain sharply separate in Matthew's three species, but in *H. matthewi* Wiman, and even more so in the new *H. confluens*, the gap is closed. Aside from the ridges, the surface of the valves is depressed; in *H. eos* and *H. minus* flat; in *H. cavatum*, rather strongly concave. A node or thin curved ridge occurs a little in front of the middle of the dorsal half of each valve. This node, though recognizable in *Beyrichona*, is much better developed in *Hipponicharion*. It is not possible with the material at hand to determine whether the edges of the two valves are perfectly equal or overlap. If overlap occurs, it is certainly only to a very limited extent. A feature of *H. cavatum*, apparently not observed by Matthew, is a narrow transversely lined marginal frill. No sign of such a frill was observed on the other two species, though the specimens of these are fully as well preserved.

HIPPONICHARION EOS Matthew

Plate 7, Figure 31

Hipponicharion eos MATTHEW, Trans. Royal Soc. Canada, vol. 3, sec. 4, 1886, p. 64, pl. 6, figs. 19, 19a, b; Trans. New York Acad. Sci., vol. 14, 1895, p. 132, pl. 7, figs. 1a, c.

Valve semielliptical with anterior and posterior ends elevated into prominent marginal ridges of about equal length, not meeting along the ventral side. These ridges are separated by a depressed flat surface which bears a low ridge near its middle, extending nearly at right angles to the hinge line near which it ends in a low inconspicuous tubercle.

Occurrence.—Lower Cambrian (Hanfordian, division C1b1); Hanford Brook, St. Martins, New Brunswick.

HIPPONICHARION CAVATUM Matthew

Plate 7, Figure 32

Hipponicharion cavatum MATTHEW, Trans. Royal Soc. Canada, vol. 11, sec. 4, 1894, p. 99, pl. 17, figs. 3a, b; Trans. New York Acad. Sci., vol. 14, 1895, p. 133, pl. 7, figs. 2a, b.

As shown by the illustration *H. cavatum* differs from the genotype *H. eos* in that the depressed surface between the marginal ridges is strongly concave instead of flat. Both the marginal ridges and the median one are narrower and higher and the latter is longer and turns at its lower end.

Occurrence.—Lower Cambrian (Hanfordian, division C1b1, C1b3); Hanford Brook, New Brunswick.

HIPPONICHARION MINUS Matthew

Plate 7, Figure 30; Plate 2, Figures 14–16

Hipponicharion minus MATTHEW, Trans. Royal Soc. Canada, vol. 11, sec. 4, 1894, p. 99, pl. 17, figs. 4a, b; Trans. New York Acad. Sci., vol. 14, 1895, p. 133, pl. 7, figs. 3a, b.

This species is quite similar to *H. cavatum*, although smaller, and differs in that the lateral ridges are low and almost join at the middle of the ventral edge. The median ridge is shorter and nearer the end of the valve.

Occurrence.—Lower Cambrian (Hanfordian, division C1b3); Hanford Brook, New Brunswick.

Plesiotypes.—Cat. No. 50552, U.S.N.M.

HIPPONICHARION MATTHEWI Wiman

Plate 2, Figures 17–20

Hipponicharion matthewi WIMAN, Bull. Geol. Inst. Upsala, vol. 6, pt. 1, 1902, p. 49, pl. 1, figs. 40–44.

As indicated in our generic notes, *H. matthewi* is related to the type of the genus, but differs conspicuously in that the gap between the marginal ridges along the ventral border is closed. It, therefore, belongs to the *H. confluens* section of the genus, differing, however, in that the dorsal ridge is at right angles to the margin, as in the typical section, instead of parallel as in *H. confluens*.

Occurrence.—Lower (Middle?) Cambrian; Glauconite sandstone: Eggegrund, Sweden.

HIPPONICHARION PLICATUM, new species

Plate 2, Figure 12

In this new well-marked species the surface between the confluent marginal rim is broken into a series of folds or plications four or five in number and arranged at right angles to the dorsal margin. The ends of the confluent marginal ridge are more strongly marked and appear to be set off as more or less separated elongated nodes. The ridge paralleling the dorsal margin is slightly developed. Lastly, the outline of the valve is more angular than other species of the genus.

Occurrence.—Middle Cambrian (Johannian-C2b): McNeil Brook, east of Marion Bridge, Cape Breton, Nova Scotia (3h).

Holotype.—Cat. No. 81624, U.S.N.M.

HIPPONICHARION PARVUM, new species

Plate 2, Figure 13

This, the smallest species of the genus so far discovered, belongs to the section in which the marginal ventral ridges are confluent. It is readily distinguished from its close ally *H. plicatum* by its more regular outline and more uniformly developed ridges which occupy the space between the confluent marginal elevation.

Occurrence.—Middle Cambrian (Johannian, division C2b): One and one-half miles west of Marion Bridge, Cape Breton, Nova Scotia (3i).

Holotype.—Cat. No. 50551, U.S.N.M.

HIPPONICHARION CONFLUENS, new species

Plate 2, Figures 10, 11

This interesting new species is readily distinguished from the more typical members of the genus by the confluent nature of the marginal ridge, which is entire and not broken, as in the type species. A node and a thin slightly curved ridge are present near the dorsal margin forming a further point of distinction.

Occurrence.—Middle Cambrian (Johannian, division C2b): One and one-half miles west of Marion Bridge, Cape Breton, Nova Scotia (3i).

Holotype.—Cat. No. 81625, U.S.N.M.

Genus POLYPHYMA Groom

Polyphyma GROOM, Quart. Journ. Geol. Soc. London, vol. 58, 1902, p. 83.

Carapace bivalved, rather small, 2 to 4 mm. in length, semielliptical or semicircular, the hinge long and straight, the ends subequal. Test thin, chitinous, pliable, surface polished, broken up into numerous

(7 to 12) large and smaller rounded elevations, the largest and most prominent of which occurs usually a little in front of the middle of the ventral edge; with or without a distinct marginal flange.

Genotype.—*Polyphyma lapworthi* Groom. Cambrian of England.

Two of the four species referred to this genus have hitherto been placed in the ostracod genus *Beyrichia*. The sole reason for the older arrangement is that the valves have nodular elevations suggesting the lobes of a *Beyrichia*. That the several nodes can not be correlated with the lobes or nodes of a true *Beyrichia*, and that all other features, notably the composition of the test, are very different, was not observed except by Holm, who with his usual acumen denied the ostracod nature of the Swedish Cambrian bivalved Crustacea and suggested placing them with the Phyllocarida.⁵ For reasons given in the introduction, the present authors regard the balance of the evidence as favoring the Branchiopoda rather than either the Phyllocarida or the Ostracoda.

Compared with other genera, *Polyphyma* seems more nearly allied to *Aluta*, *Beyrichona*, and *Hipponicharion* than to any of the other generic groups. *Lepiditta* and *Isorys* also are suggested by their shapes, but it is not believed that the relations to either of these genera is at all close. At any rate the shell of *Lepiditta* is thought to have been more calcareous, while the absence of surface nodes affords an obvious criterion in separating the two groups. As to *Isorys*, its shell was probably not materially different, but considering its nontuberculated valves and the fact that its species grew to such greater size, all thought of genetic relation to *Polyphyma* is dismissed from the investigator's mind.

Reverting to the true allies of the genus, it is distinguished from *Aluta* (as herein defined) and *Beyrichona* by its more nearly semi-circular outline and numerous, comparatively variable tubercles. *Hipponicharion*, possibly, is the nearest of these true allies, but is readily distinguished by the segregation of most of the nodes into a continuous or medially divided submarginal ridge, which gives it a very characteristic, regular aspect that is strikingly different from the apparently irregular arrangement of the tubercles in *Polyphyma*.

The adopted orientation of the valves is based on the correlation of the largest of the ventral nodes with the antero-ventral node in *Aluta*. This is located a little to one side of the middle—presumably the anterior—in *Polyphyma*.

⁵ Holm, G., Sveriges Kambr.-Silur. Hyolithidae, 1893, p. 110, foot note (Sveriges Geol. Unders., ser. C, No. 112).

POLYPHYMA LAPWORTHII Groom

Plate 8, Figures 26, 27

Polyphyma lapworthi GROOM, Quart. Journ. Geol. Soc. London, vol. 58, p. 84, pl. 3, figs. 1-8.

This species, the genotype of *Polyphyma*, is fully described and illustrated by Groom, so that it is only necessary to point out its chief characteristics as indicated by him and as shown in the reproductions of his original figures on Plate 8. These are a subcentral parallel direct reniform elevation, three tubercles near the dorsal margin and an anterior subtriangular lobe.

Occurrence.—Lowest black shales (Cambrian): Southern Malverns, England.

POLYPHYMA MARGINATA, new species

Plate 8, Figures 28, 29

Description.—Valves semicircular, the height slightly greater than half the length of the hinge line. Surface now rather depressed convex, originally probably ventricose, with 10 to 12 partly confluent rounded nodes separated by narrower depressed spaces. Eight of these are small and in part inconspicuous and arranged closely along the dorsal and posterior margins, while a low ridge parallels the front border. Two much larger nodes, both somewhat crushed in the best specimen, occupy the middle part of the ventral half. The hinder of these two elevations is low and broad based, the forward one a little smaller at the base but rising to a much greater height; whether rounded at the summit or conical can not be determined. A narrow, sharply defined rim forms the extreme edge on the anterior ventral and dorsal sides. Within this the best specimens exhibit two distinct parallel folds, which become obsolete in the post-ventral part and possibly were produced by compression of the pliable test.

Dimensions of the largest and best specimen, the right valve figured on Plate 8: Length of hinge line about 3.2 mm., greatest height 2.0 mm.

Occurrence.—In black shales classified as upper Cambrian by Doctor Walcott, west side of Manuel's River, Conception Bay, Newfoundland.

Holotype.—Cat. No. 56492, U.S.N.M.

Remarks.—The half dozen or more specimens of this species in the National Museum collection have been subjected to more or less compression; and as they lie variously with respect to its direction, they exhibit a corresponding variety of distortion. Thus, when they lie so that the length is reduced to about half, the nodes seem to arrange themselves in four irregularly undulating vertical ridges. But as each specimen looks different from the others, it is useless

to describe them. Only one, the figured type, seems to retain approximately the normal outline and arrangement of the nodes, and even this was injured along its anterior edge in removing the matrix. Additional material is therefore most desirable.

Excepting the next following species, no other known Paleozoic fossil is at all likely to be confused with good examples of *P. marginata*. From *P. angelini* and *P. armata*, both Swedish species and evidently from older rocks, it is distinguished at once by the marginal rim and folds which seem to be wanting or but ill developed in its foreign congeners.

POLYPHYMA ANGELINI (Barrande)

Plate 8, Figure 30

Beyrichia angelini BARRANDE, Syst. Sil. du Centre Boheme, vol. 1, Suppl., 1872, p. 485.—LINNARSSON, Sveriges Geol. Unders., ser. C, No. 21, 1875, p. 45, pl. 5, fig. 11; Ofvers. k. Vet.-Akad. Forhandl., vol. 32, 1875, p. 43, pl. 5, fig. 11.

All that has been learned concerning this apparently well-marked Swedish species is shown in the photographic reproduction on Plate 8 of the illustration originally published by Linnarsson. According to this the valves are semielliptical, the extremities of the hinge equally sharp, and the height less than half the greatest length, which is about 2.8 mm. A large tubercle is located near the middle of the ventral half, while seven or eight smaller nodes are irregularly distributed over the rest of the surface. The figure does not show a marginal rim, nor is such a feature mentioned in Linnarsson's description. The absence of the rim and of parallel folds within it would suffice in distinguishing the species from its American congener. It may be added further that the outline differs also in that the hinge is relatively longer and the extremities more sharply angular.

Occurrence.—Upper Cambrian, Olenus beds, Andrarum, Sweden.

POLYPHYMA ARMATA (Grönwall)

Plate 8, Figure 31

"*Beyrichia*" *angelini* var. *armata* GRÖNWALL Danmarks Geol. Unders., II Raekke, No. 13, 1902, p. 163, pl. 4, fig. 7, p. 220.

This form also is known to the authors only from the figure and description published in the Swedish report cited above. Grönwall distinguished it as a variety of *P. angelini*, but, assuming the published figures of the two forms to be correct, it is thought a specific separation would have been justified. The principal peculiarity of *P. armata* lies in the extraordinary development and confluence of the dorsal nodes, which in both of the other species of the genus are much smaller and more numerous. Then there are two conical tubercles that project beyond the ventral edge and add to the dis-

tinctive features of the species. These two ventral nodes probably represent the submarginal folds of *P. marginata*, while the tubercle just above the anterior one of the two is regarded as corresponding to the principal node in *P. angelini* and *P. marginata*. The dimensions as given by Grönwall are as follows: Length 3.0 mm., height 1.4 mm.

Occurrence.—Middle Cambrian, Davidis zone, near Borregaard, Bornholm, Denmark.

Family INDIANIDAE new family

Small oval bivalved Conchostraca with surface of valves even, smooth, and not exhibiting an ocular tubercle. Valves open along the anterior and posterior ends and widely gaping along the ventral edge. Shell structure corneo-calcareous, polished.

Genus INDIANA Matthew (emended)

Indiana MATTHEW (part), Canadian Rec. Sci., vol. 8, 1902, p. 460; Geol. Surv.

Canada, Rep. Cambrian Rocks Cape Breton, 1903, p. 169.

Not *Indiana* JONES, Geol. Mag., Dec. 4, vol. 9, 1902, p. 402.

Carapace bivalved, rather small, 4 to 7 mm. long, the outline a more or less obliquely truncated ellipse, the hinge being straight but of varying length and sharpness of definition. Anterior extremity commonly bowed forward from the antero-dorsal angle, at other times descending vertically from the angle. Postcardinal angle obtuse, occasionally rounded off, more commonly distinct. Posterior margin broader than the anterior, sometimes following a regular elliptic curve, oftener obliquely truncated or even slightly concave in the upper part. Valves rather strongly convex, usually somewhat depressed in the anterior half of the dorsal slope; without nodes. Free edges of valves with or without a delicate external rim, occasionally expanding into a wide, flattened border sometimes developed only on the anterior end; inner side of edge bent inward. Gap between edges of opposite valves widest at the ends, chiefly made up by concavity of the ends of the left valve. Test thin, black to brown or yellow, polished, minutely punctate, somewhat pliable chitinous, including very little calcareous matter in its composition.

Genotype.—*Indiana lippa* Matthew (selected by the writers).

Remarks.—In the original description of *Indiana* by Matthew⁶ no genotype was designated. The first species following the generic diagnosis is *I. ovalis*, and this species, under the rules generally prevailing in such cases, has been cited as the genotype. Unfortunately, as has been already mentioned in discussing *Bradoria*, the genus can not be maintained if founded on *I. ovalis*. The imperfect original type of this species, after careful comparison, was positively identified

⁶ Canadian Rec. Sci., vol. 8, 1902, p. 460.

with a good species of *Bradoria* in the collections of the National Museum from the same locality. Being distinct, the specific name is retained and the species accordingly has been described on a preceding page under the name *Bradoria ovalis*.

As detailed on a former page, still another of the species referred to *Indiana* by Matthew in 1902 belongs to *Bradoria*, namely, the form described by him in 1898 as *Aparchites? robustus*. The synonymy of this species is very complicated, the study of Matthew's collection of original types having shown that he gave no less than five names, distributed among three genera, to different individuals of one and the same species.

The hitherto accepted genotype of *Indiana* being an unqualified *Bradoria*, the former genus must either fall into synonymy under the latter, or be restored to good standing by the selection of another genotype. The latter course is thought the more advisable, because the genus, as constituted by Matthew, includes a distinguishable group of species, the essential characters of which are brought out in the above revised definition of *Indiana*. Of the other species originally referred to the genus by Matthew, *I. lippa* and *I. pyriformis* are perhaps equally characteristic of the revised genus. The type specimen of the former being rather better preserved than the other, it is selected as the genotype.

Based on *I. lippa* and *I. pyriformis*, both of Matthew, and including the congeneric *Aparchites secunda* Matthew, *Lepeditia dermatoides* Walcott, *L. primaeva* Matthew, *Primitia acadica* Matthew, *Aparchites anderssoni* Wiman, and the new species of the present work, *I. longula*, *I. suberecta*, *I. matthewi*, *I. labiosa*, *I. faba*, *I. curta*, and *I. impressa*, the genus *Indiana* is distinguished from *Bradoria* by the entire absence of ocular and other tubercles. Other differences are found in the greater gap in the ends and ventral parts of the carapace, and in the slight inequality of the dorsal parts of the valves, the margin of the left valve in at least some of the species, extending over the median line of the back so as to overhang the gaps. Again, in most of the species of *Indiana*, the outline of the valves has a retral swing that is quite foreign to the average *Bradoria*. Further, it is to be noted that the angulation of the posterior and anterior parts of the outline frequently seen in species of *Bradoria* is either entirely absent or barely distinguishable in *Indiana*. Finally, the surface of the species to which it is proposed to restrict *Indiana* has, despite its fine punctation, a polish that is never observed in *Bradoria*.

On account of the usual imperfections resulting from crushing, folding, and breakage of the carapaces prior to fossilization, it is likely that some difficulty may be experienced in distinguishing certain forms from species belonging to the new genus *Mononotella*, founded on the species originally described by Matthew as *Primitia? fusiformis*.

mis, but later referred by him to *Indiana*. In this new genus the carapace, instead of consisting of two valves, is composed of a single plate folded in such a manner that only perfect specimens are readily distinguished from *Indiana*.

For a discussion of the relations of *Indiana* to *Walcottella* and *Dielymella*, see the remarks under the descriptions of those genera.

INDIANA LIPPA Matthew

Plate 9, Figures 1-4

Indiana lippa MATTHEW, Canadian Rec. Sci., vol. 8, 1902, p. 463, pl. 2, figs. 10a-10d; Geol. Surv. Canada, Rep. Cambrian Rocks Cape Breton, 1903, p. 171, pl. 13, figs. 10a-10d.

Description.—Carapace subovate, widest posteriorly, hinge slightly exceeding half of the greatest length, cardinal angles obtuse but definite, anterior margin rounded, ventral margin broadly convex, posterior outline strongly convex in lower two-thirds, straight in upper third to the dorsal angle. Valves moderately convex, slightly depressed in the antero-dorsal region; with a broad, obscurely defined ventral border turned inward at the extreme edge. Test very thin, black and shiny in the dark matrix, minutely punctate.

Dimensions of the best and most typical of the National Museum's specimens: Greatest length 5.2 mm., length of hinge line 2.8 mm., greatest height 3.1 mm., thickness about 2.7 mm.

Remarks.—The original types of this species consist of a complete carapace and the cavity from which it was removed. Four specimens, one precisely like Matthew's type, the other less confidently referred, were detected in the Walcott collections. Judging from all these specimens, the species occupies an intermediate position between *I. secunda*, *I. pyriformis*, and *I. dermatoides*, on the one hand, and *I. acadica* and *I. primaeva* on the other. In the first three species the posterior half is proportionally wider, and hence the ventral edge more oblique; in the latter two, the two ends of the valves are less unequal and the ventral and dorsal sides of the outline therefore more nearly parallel. The anterior end being rounded as in *I. secunda* and *I. pyriformis*, the present species is thought to be more closely allied to these than to *I. dermatoides* and *I. primaeva*, in which the antero-dorsal angle is more prominent and the upper part of the anterior outline nearly vertical.

The contour of the valves is rather strongly convex in all of these species and the surface markings, consisting of minute, widely separated punctae, are not materially different. An obscure unbonal angulation extending obliquely backward from the antero-dorsal angle is perhaps a more prominent feature in *I. lippa* than in the others.

Occurrence.—Lower Cambrian (Upper Etcheminian-div. E3e, E3f) Dugald Brook, Cape Breton. Occurs also in the Hanfordian Clb3, Hanford Brook, New Brunswick.

Plesiotypes.—Cat. Nos. 56474–56476, U.S.N.M.

INDIANA SECUNDA (Matthew)

Plate 9, Figures 5–8

Aparchites secunda MATTHEW, Trans. New York Acad. Sci., vol. 14, 1895, p. 136, pl. 7, figs. 11a, 11b.

Description.—Carapace obliquely subovate, much narrower in front than behind; hinge straight, somewhat exceeding half the length of carapace, the anterior angle fairly distinct, the anterior margin obliquely subtruncate, extending a little beyond the angle, rounding sharply below into the gently convex and anteriorly ascending ventral margin; posterior end long and wide, strongly rounded in outline except the upper third, which rises with a straight slope to the obtuse but clearly defined postcardinal angle. Valves strongly convex, with or without a very narrow, barely distinguishable rim; gap rather wide at both ends and along ventral side. Surface of shell polished and punctated as usual.

Dimensions of typical specimen: Greatest length (obliquely across carapace) 4.1 mm., length of hinge line 2.8 mm., greatest height 2.8 mm., thickness about 2.1 mm.

Remarks.—Matthew's collection of types contains three specimens. One of these, an entire carapace, was figured by Matthew and is the original of Figure 5 on Plate 9. It is, therefore, regarded as the holotype. The other two specimens are somewhat imperfectly preserved valves, but, so far as can be seen, belong to the same species as the type.

Matthew's figure of the left side of the type represents the ventral margin as more convex, and consequently the height of the posterior half as somewhat greater than it is in the original. The dorsal angles also are too much rounded in his illustration. These slight inaccuracies are corrected in Figure 6 on the same plate.

The relatively narrow anterior extremity and the pronounced retral swing of the outline serve to distinguish the species from *I. lippa*. In *I. lonqula*, however, both of these features are developed to an even greater extent. *I. dermatoides* is a close ally, and the discrimination of the two forms may occasionally prove difficult. However, with good specimens the nearly rectangular antero-dorsal part of the outline and the more convex ventral side of *I. dermatoides* make the task of separation reasonably easy.

Another very close alliance seems to be with *I. anderssoni* (Wiman) from the Glauconite sandstone of Sweden. Wiman's type evidently is somewhat crushed; but if the outline as represented in the illustra-

tions of the Swedish species is correct, it may be distinguished as a variety by its more prominent and sharply rounded anterior extremity.

Occurrence.—Lower Cambrian (Hanfordian Protolenus zone, division C1b2), Hanford Brook, St. Martins, New Brunswick. Seven specimens in the United States National Museum, collected by Doctor Walcott in Greenwich Township, Washington County, N. Y., occurred in an arenaceous limestone referred by him to the Lower Cambrian. Cat. No. 56467, U.S.N.M.

INDIANA ANDERSSONI (Wiman)

Plate 9, Figures 22–25

Aparchites? anderssoni WIMAN, Bull. Geol. Institut. Upsala, vol. 6, pt. 1, 1902, p. 45, pl. 1, figs. 25–28.

All the available information concerning this species is contained in the description and figures published by Wiman. Judging more especially from the latter, the species is thought to be founded on a crushed example of an *Indiana* closely related to *I. dermatoides* and *I. secunda*. Compared with the latter the only difference noted that is not manifestly the result of injury lies in the more prominent and narrowly rounded anterior extremity. Even this difference may have been produced by the injury and loss of the anterior cardinal angle. Only a restudy of Wiman's type specimens with these possibilities in mind can determine the validity of the species and its true relations to the American species.

Occurrence.—Lower (? Middle) Cambrian, Glauconite sandstone; Eggegrund, Sweden.

INDIANA PYRIFORMIS (Matthew)

Plate 9, Figures 11, 12

Primitia pyriformis MATTHEW, Trans. Royal Soc. Canada, ser. 2, vol. 4, sect. 4, 1898, p. 132, pl. 1, figs. 3 a–c.

Indiana pyriformis MATTHEW, Canadian Rec. Sci., vol. 8, 1902, p. 461.

This form is represented in the Matthew's collection of types by two specimens from Long Island, New Brunswick, both left valves of exactly the same shape. The surface in both is somewhat injured by exfoliation and corrosion, but retains sufficient evidence of its character to prove that it is finely punctated as in *I. secunda*. Carefully compared with the types of that species, few differences, and hardly any of consequence, were noted save in the matter of size, the types of *I. pyriformis* being nearly twice as long as those of *I. secunda*. However, as two specimens from Hanford Brook and two others from Washington County, N. Y., in the United States National Museum, hold the same dimensions, and as none of intermediate size is known, it is thought advisable to maintain the two forms as dis-

tinct—whether as varieties or good species to be determined hereafter. In distinguishing them, after the great difference in size, it is to be noted that the valves of *I. pyriformis* are relatively wider in front, the hinge is longer, and the postdorsal angle not so broad, while the posterior margin turns downward more rapidly. In consequence of these small peculiarities, the retral swing of the outline is less striking than it appears in *I. secunda*.

In the figure of a left valve published by Matthew the angular form of the postcardinal region is not so well brought out as in the right valve represented by our new figure. Critically compared, a slight difference in thickness of valves is noted between the New Brunswick and New York specimens. The latter are less convex than the former but the difference is due, in part at least, to compression.

Dimensions: Greatest length (diagonally across the carapace) 6.8 mm., length of hinge 4.1 mm., greatest height 4.7 mm., thickness of right valve 1.7 mm.

Occurrence.—Lower Cambrian (Hanfordian, division C1b31), Long Island, Kings County, New Brunswick; Hanford Brook, St. John County, New Brunswick. In Washington County, N. Y., the species occurs in association with *I. dermatoides* and *I. secunda*, in limestone correlated as Lower Cambrian by Doctor Walcott.

Plesiotype.—Cat. No. 56470, U.S.N.M.

INDIANA LONGULA, new species

Plate 9, Figures 19–21

Description.—Carapace larger than usual for the genus, obliquely subelliptical, produced posteriorly, the postventral extremity narrowly rounded; anterior end small, truncated vertically with respect to the hinge line; hinge short, less than half the greatest diameter of carapace; post-dorsal angle undefined, the anterior conspicuous but rounded off. Other features apparently the same as in *I. secunda*.

Dimensions: Greatest length (measuring from the antero-dorsal angle to the post ventral margin) 7.5 mm., length of hinge about 4 mm., width from middle of ventral side to the post dorsal edge 4.5 mm., thickness 3.5 mm. or more.

Remarks.—But a single example of this species has been seen. It retains both valves in nearly perfect condition. The edges of the valves have all the appearance of overlapping along the ventral side as in *Leperditia*, but this condition is most probably abnormal. That it resulted from the valves being forced together is indicated by the ragged edge of the overlapping (left) valve, as shown in our figure.

Except that the specimen is much larger, it bears a striking general resemblance to *I. secunda*. On closer comparison, however, it is

observed that the anterior edge of *I. longula* is less rounded and more nearly rectangular with respect to the hinge line, the postero-dorsal part of the outline more rounded, the posterior terminus of the hinge ill-marked, the postventral extremity more prolonged, and the angle of the longest axis of the carapace to the hinge line wider. In the last respect *I. longula* agrees with *I. pyriformis*, but the postdorsal angle is so much better developed in that species that these two forms, despite the fact that they are nearly equal in size, are not likely to be confused. A closer ally than either of the former seems to be indicated in *I. dermatoides*, a New York species of nearly the same age. Still the latter is easily distinguished by its more sharply defined cardinal angles, less oblique form, and less narrowly rounded posterior extremity. It is also a smaller form. Another close relative is the new *I. suberecta*, but the shorter hinge and more erect habit of the latter are such striking differences that a glance suffices in distinguishing them. The other remaining species referred to *Indiana* are too obviously different to require comparison.

Occurrence.—Lower Cambrian (Hanfordian division C1b3); Hanford Brook, St. John County, New Brunswick.

Holotype.—Cat. No. 50558, U.S.N.M.

INDIANA SUBERECTA, new species

Plate 9, Figure 28

Description.—Carapace slightly exceeding the average for the genus in size, subelliptical in outline, truncated dorsally so that when the hinge is placed horizontally the habit is more nearly erect than in any other species; anterior side and hinge line forming a right angle, postdorsal angle obtuse but fairly distinct; ventral margin very gently convex, the turn into the anterior edge rather abrupt but not angular; posterior outline strongly convex in the lower third, gently rounded in the middle third, and straight, with a decided anterior inclination, in the upper third; between the middle and upper thirds an obtuse angulation; hinge line short, its length barely exceeding one-third of the greatest diameter of carapace. Valves moderately convex, thickest in the posterior half, with blunt, rimlike edges. Test black, with very minute, crowded punctae, distinctly visible only under a high power of magnification.

Dimensions of type specimen, a right valve: Greatest diameter (from antero-dorsal angle to postventral edge) 5.2 mm., length of hinge line (slightly imperfect) about 2 mm., greatest width of posterior half (measuring diagonally across valve) 3.2 mm., greatest thickness about 1.1 mm.

Remarks.—This species is distinguished by its comparatively erect habit and short hinge. In both features it is approached by *I. lon-*

gula, but that species is readily separated by its more narrowly rounded posterior extremity and more uniformly rounded postdorsal edges. It is also allied to the associated *I. dermatoides*, but the punctation of its test is more minute and more crowded, and when properly oriented the shape of the valves is quite different.

Occurrence.—Lower Cambrian, limestone outcropping on Reid's farm, 1½ miles north of Bald Mountain, Greenwich Township, Washington County, N. Y.

Holotype.—Cat. No. 56469, U.S.N.M.

INDIANA DERMATOIDES (Walcott)

Plate 9, Figures 16, 17

Leperditia dermatoides WALCOTT, Amer. Journ. Sci., ser. 3, vol. 34, 1887, p. 192, pl. 1, figs. 13, 13a; 10th Ann. Rep. U. S. Geol. Surv., 1890, p. 626, pl. 80, figs. 1, 1a.—MATTHEW, Amer. Geol., vol. 8, 1891, p. 290.—COBBOLD, Quart. Journ. Geol. Soc., vol. 76, 1921, p. 368.

Indiana dermatoides CHAPMAN, Proc. Royal Soc. Victoria, new ser., vol. 31, 1918, p. 109.

Description.—Carapace of medium size, subelliptical in outline, the ellipse obliquely truncated along the hinge line; dorsal angles distinct, the anterior about 100°, the posterior about 135°; hinge less than half the total length of carapace, constructed seemingly so that in its posterior half the edges of the opposite valves overlap; anterior end narrow, the outer margin curved gently and so that its most prominent point projects but slightly beyond the dorsal angle; ventral part of outline moderately convex, trending obliquely backward toward the posterior extremity, around which the outline continues with a semicircular curve; upper third of posterior margin nearly straight. Valves moderately convex, highest in the posterior half, the slope near the antero-dorsal half rather more abrupt than elsewhere; apparently without a flattened rim. Test thin, black, distinctly punctate; punctae rather closely arranged.

Dimensions of left valve (original type of species): Greatest length 5.9 mm., length of hinge line 3.1 mm., distance from middle of ventral edge to postdorsal angle 3.3 mm., thickness about 1.3 mm.

Remarks.—The original collections used by Doctor Walcott in describing this well-marked species proved to contain at least two distinct forms, the second being now referred to *I. secunda* (Matthew). Other specimens of the original lot are either too imperfect or insufficiently prepared to admit of definite classification. A third species, *I. suberecta* of this work, does occur in the same bed, and it is therefore not improbable that it also is represented among the undetermined specimens.

Critically compared with the other species of *Indiana*, *I. dermatoides* appears more or less closely allied to *I. secunda*, *I. pyriformis*,

I. longula, and *I. suberecta*. From the first and second of these allied species it is readily distinguished by its shorter hinge line and correspondingly more produced posterior end. The differences are quickly noted in comparing the truncation of the species. For the same reasons the posterior half of the valves appears to be narrower in *I. dermatoides*. The other two species, *I. longula* and *I. suberecta*, differ in the opposite direction. In both the hinge line is even shorter, and when this line is placed horizontally their carapaces appear more erect. The latter difference is best shown by the strong downward trend of the anterior and ventral sides from the horizontal hinge line. A closer relative, perhaps, than any of the named species is indicated in the following *I. matthewi*. For comparisons see remarks under that species.

Occurrence.—In thin limestone intercalated in or overlying the Cambrian roofing slate referred to the Lower Cambrian by Doctor Walcott at several localities in Greenwich Township, Washington County, N. Y. A single specimen, injured in front, and therefore somewhat doubtfully referred to the species, is from the "Middle Cambrian" (C1c) at Hastings Cove, Kennebecasis River, 6 miles east of St. John, New Brunswick. Identified by Cobbold in the Lower Cambrian limestone with *Strenuella* at Comley, England.

Holotype.—Cat. No. 17474, U.S.N.M.

INDIANA MATTHEWI, new species

Plate 9, Figure 15

Description.—Carapace small, obliquely subovate, narrowing anteriorly, hinge line three-fifths of greatest length, postdorsal angle obtuse, sometimes even rounded off, anterior angle sharply defined, almost rectangular; anterior margin scarcely bowed in upper part, the curve from the dorsal angle to the postventral side decreasing very gradually and on the whole gently; posterior margin more strongly convex, with greatest prominence in lower half; upper half oblique, in most instances appreciably straightened. Valves without rim, but the anterior edge, especially of the left valve, is sometimes raised slightly as though to widen the gap between the valves; surface moderately convex, the highest point a little behind the center; a more or less obvious but wide and undefined depression in the dorsal slope. Test light brown or black, smooth and sometimes polished, apparently not punctate.

Dimensions of largest specimen: Greatest length 4.0 mm., length of hinge line 2.3 mm., greatest height 2.8 mm., thickness (of single valve) about 1.15 mm.

Remarks.—In most respects this species occupies an intermediate position between *I. secunda* and *I. dermatoides*. It differs from both in the more rectangular form of the antero-cardinal part of the

outline, in the greater convexity of the ventral margin, and in its non-punctate test. From the former it differs further in the proportionately greater height and hence in its more broadly rounded posterior end. Its average size, finally, is somewhat greater. It is considerably smaller than the average for *I. dermatoides*, has a relatively longer hinge line, and is less produced posteriorly. In its departure from these two species, *I. matthewi* approaches *I. primaeva* (Matthew), which see for comparisons.

Occurrence.—Middle Cambrian (Acadian-Paradoxides zone C1c), Hastings Cove, Kennebecasis River, 6 miles east of St. John, New Brunswick (2s) (holotype); one specimen from the Hanfordian, upper part of C1b3 of Matthew's *Protolenus* zone, at Hanford Brook, St. John County, New Brunswick.

Holotype.—Cat. No. 50555, U.S.N.M.

INDIANA PRIMAeva (Matthew)

Plate 9, Figures 9, 10

Leperditia (?) *primaeva* MATTHEW, Trans. New York Acad. Sci., vol. 14, 1895, p. 138, pl. 8, figs. 6a, b.

A good right valve and two left valves in the collections of the National Museum agree in all respects save size too closely with Matthew's description and figure of *Leperditia? primaeva* to justify specific separation. His type is from Hanford Brook, where it occurred in the lower part of assize 3 of Matthew's section. Unfortunately it was not included in the collection of types loaned by the Toronto University. The specimens in the United States National Museum were collected by Walcott at Hastings Cove from apparently the same general horizon as assize 3 of the Hanford Brook section. They belong to an unquestionable species of *Indiana* as here revised, but without seeing Matthew's figured type of *L.? primaeva*, hesitancy is felt in stating positively that it belongs to the same genus and species, although the inclination to this belief is strong. Taking the characters chiefly from the specimens in hand, *I. primaeva* may be briefly described as follows:

Description.—Carapace subovate, relatively shorter and less oblique than usual; hinge long, cardinal angles well defined, the anterior and dorsal edges forming an angle of about 100°, the posterior angle much wider; ends unequal, though less so than in preceding species; lower half of the anterior outline turning backward with a full curve in both valves, but the upper half varies in the two valves, being nearly rectangular in the right and rounded in the left; posterior margin broadly rounded below, nearly straight in the upper third in the right and straight or even a trifle concave in the left; ventral outline rather strongly convex, ascending somewhat faster toward the front. Valves strongly convex, without nodes, but showing an ill-defined yet in certain lights not inconspicuous

depression in the middle of the anterior two-thirds of the dorsal slope. An obscure flattening, caused by a slight elevation of the anterior margin and resulting in a corresponding increase in the gap between the valves, is noticeable on the left valve but not on the right. Test very thin, light brownish to black in color, very minutely and faintly punctate, polished.

Dimensions of right valve: Greatest (diagonal) length 3.4 mm., greatest horizontal length 3.3 mm., length of hinge 2.0 mm., greatest height 2.7 mm., thickness about 1.2 mm. Judging from the figure of Matthew's type of *L. primaeva* its length is approximately 5.1 mm.

Remarks.—In forming the conclusion that the Hastings Cove specimens are referable to *I. primaeva*, the right valve shown in Figure 10 on Plate 9 is chiefly relied on. In comparing this valve with Matthew's figure of *Leperditia? primaeva*, reproduced on the same plate, it will be observed that the former is somewhat wider posteriorly and that the dorsal angles are sharper. These differences, however, may very well be due to incomplete preparation of Matthew's type, a possible criticism for which there has been frequent occasion in the course of the present studies, respecting the original figures of that author's species of bivalved Crustacea. A narrow strip of matrix covering the posterior parts of either the dorsal or ventral edges of the Hastings Cove specimen would cause its exposed parts to agree almost exactly with Figure 9. Even if the type proves to have been perfectly prepared, its apparent peculiarities, regarding its greater size, are scarcely of sufficient importance to warrant specific distinction.

As figured by Matthew, *I. primaeva* should be closely related to the Grand Canyon species *I. faba*, which is distinguished solely on the assumption that Matthew's type is not accurately represented by the original illustration. Should this assumption prove ill-founded, then *I. faba* would become a synonym or variety of *I. primaeva* (Matthew) (not Ulrich and Bassler) and *I. primaeva* Ulrich and Bassler (not Matthew), would be subject to renaming.

Some misgivings may arise in the minds of students concerning the propriety of referring the obviously different left valves to this species. It is done chiefly for the reason that *I. matthewi* has similarly differing valves. Indeed, these two species are closely allied, differing chiefly in the fact that *I. primaeva* is relatively shorter.

Occurrence.—Lower Cambrian (Hanfordian C1b3) at Hanford Brook, St. Martins, New Brunswick. The United States National Museum specimens were collected from apparently equivalent beds at Hastings Cove, Kennebecasis River, about 6 miles east of St. John, New Brunswick.

Plesio-type.—Cat. No. 56465, U.S.N.M.

INDIANA LABIOSA, new species

Plate 9, Figures 26, 27

Description.—Carapace exceeding the average in size, rather elongate subelliptical in outline, but slightly oblique, dorsal edge straight, fully two-thirds as long as the greatest length of carapace; dorsal angles well defined, the anterior sharper than the posterior; ends subequal, rounded, the posterior extending a trifle farther beyond the dorsal angle than does the anterior; ventral part of outline moderately convex, somewhat produced and obtusely angular near the middle. Surface of valves moderately convex, originally probably well rounded, in the present compressed condition appearing somewhat flattened in the median portion and relatively steep adjacent to the margin; ventral margin with a distinctly flattened rim becoming gradually obsolete as it passes round the ends. Test mostly destroyed by solution, the delicate remnants along the dorsal and ventral edges black; surface markings unknown.

Dimensions: Length 5.8 mm., greatest height, including ventral border, 4.0 mm., excluding border 3.6 mm., thickness of right valve 1.0 mm. or more.

Remarks.—The broad flattened ventral rim gives this species an aspect not shared by any other of the genus known. In general form it is greatly like Matthew's figure of his *Leperditia? primaeva* but somewhat less in accord with the specimens tentatively referred to that species under the name *Indiana primaeva*. *I. labiosa* differs from both in being larger and relatively more elongate besides having a flat border unlike anything seen in *I. primaeva*. The two species from the Bright Angel shale next described are probably its closest known allies. The reader is referred to the remarks following the descriptions of those species for detailed comparisons.

Occurrence.—Middle Cambrian, Stephen formation, in bed 2*d* of Walcott's section at Mount Bosworth, British Columbia.⁷

Cotypes.—Cat. No. 56464, U.S.N.M.

INDIANA FABA, new species

Plate 5, Figures 10-14

Description.—Carapace of medium size, subovate, moderately inequilateral; hinge straight, about two-thirds as long as the greatest diameter, its extremities sharply defined in the dorsal angles; ends subequal, the posterior the more produced and more strongly rounded in its lower half than the anterior; ventral margin rather strongly convex. Surface of valves without nodes, moderately convex, the point of greatest elevation in front of the middle; without a flattened

⁷ See Smithsonian Miscellaneous Collections, No. 1812, p. 211.

border. Test thin, white to brown, smooth, occasionally with obscure, very minute, crowded punctae.

Dimensions: Length 5.1 mm., greatest height 3.9 mm., thickness of entire carapace 2.2 mm.

Remarks.—As already mentioned, this form is greatly like the original figure of *I. primaeva* (Matthew). For reasons given it is thought that this figure may not be entirely accurate, but in the absence of the type specimen this point could not be determined positively. In the meantime, having referred to *I. primaeva* certain specimens that are clearly distinct from this Arizona species, it became necessary to apply a different name, namely *I. faba*, to the latter. Even in the event that *I. primaeva* proves to have been correctly figured by Matthew, the new name *faba* may still be retained in a subordinate sense, because the specimens to which the latter name is here applied are relatively a little higher than Matthew's specimen.

Compared with other species of the genus described on preceding pages, only *I. labiosa* is at all similar. Even this is easily distinguished, being longer and having a well defined ventral border. The following *I. curta* is still shorter, but *I. impressa* is proportionately longer and has an undefined, broad mesial depression.

Occurrence.—Middle Cambrian, Bright Angel shale, Grand Canyon of the Colorado, Ariz. Most of the specimens are from the Chuar Valley. Three specimens from just above the massive sandstone of the formation near mouth of Bass Canyon. The latter were associated with most of the species of *Walcottella* described in this work.

Cotypes.—Cat. Nos. 56458, 56459, U.S.N.M.

INDIANA FABA INTERMEDIA, new variety

Plate 5, Figure 15

A single specimen in a fair state of preservation differs too much from average examples of *I. faba* to be referred to it without qualification. With more specimens it might be distinguished as a good species; but having noted but a single example, and this slightly distorted by pressure, it is thought best to separate it only as a variety. Compared with the typical form of the species, it is found to be proportionally longer, its ends more equally curved so that it is difficult to distinguish the anterior from the posterior, the central part of the surface less convex, and the punctae of the test more distantly arranged. The last fact possibly indicates more important genetic differences than can be made out with the material now available for study.

Occurrence.—Bright Angel shale, just above the lower massive sandstone, Chuar Valley, Grand Canyon of the Colorado, Ariz.

Holotype.—Cat. No. 56462, U.S.N.M.

INDIANA CURTA, new species

Plate 5, Figure 9

This species is founded on a single left valve so much like *I. faba* that a detailed description may be dispensed with. However, in looking over the material of *I. faba*, which consists of more than 30 specimens, this valve was at once separated on account of its comparatively short form. The difference in this respect is clearly shown by the illustrations of the two forms on Plate 5. *I. curta* is probably merely a well marked variety of *I. faba*, but in the absence of satisfactory intermediate stages, it has been thought preferable to view it provisionally as a distinct species.

Dimensions: Length 4.25 mm., height 3.51 mm.

Occurrence.—Bright Angel shale, just above massive lower sandstone, near mouth of Bass Canyon, Grand Canyon of the Colorado, Ariz.

Holotype.—Cat. No. 56466, U.S.N.M.

INDIANA IMPRESSA, new species

Plate 10, Figure 2

Description.—Carapace of medium size, obliquely subovate, the ends nearly equal in width; dorsal edge straight, nearly three-fourths the length of the valves; cardinal angles readily determinable but not sharply defined, apparently more obtuse in the left than in the right valve; anterior margin with greatest prominence and curvature in the upper half, trending backward in the lower half; posterior margin strongly rounded in the middle and lower thirds, occasionally, as in the figured specimen, slightly truncate in the upper third; ventral margin gently convex, its course in general approximately paralleling the hinge. Surface of valves on the whole gently convex, broadly depressed in the median third, sloping rapidly at the ends which are blunt; an ill-defined furrow within the ventral edge forms a rather wide, flattened border that dies out before reaching the ends. Test white or brown, smooth, apparently not punctate.

Dimensions: Length 4.1 mm., height 2.7 mm., greatest thickness about 1.0 mm.

Remarks.—This species is readily distinguished from all others referred to the genus by the broad median depression of the surface. Of known forms it is perhaps nearest *I. faba* var. *intermedia*, but as this also is without the median depression and differs further in minor details of outline, and in the more important fact that it has no furrow in the ventral slope, there is little excuse for confusing them.

In its most characteristic feature *I. impressa* suggests *Dielymella dorsalis*, which also occurs in the Bright Angel shale. However,

the mesial depression is less conspicuous in that species, and this, together with obvious differences in outline and size, preclude the possibility of specific identity. As to their generic relations there is less certainty.

Occurrence.—Bright Angel shale just above lower massive sandstone, near mouth of Bass Canyon, Grand Canyon of the Colorado, Ariz.

Holotype.—Cat. No. 56463, U.S.N.M.

DOUBTFUL SPECIES

INDIANA ? ACADICA (Matthew)

Plate 9, Figure 13

Primitia acadica MATTHEW, Trans. Royal Soc. Canada, vol. 3, sec. 4, 1886, p. 66, pl. 6, figs. 22, 22a, b; Trans. New York Acad. Sci., vol. 15, 1896, p. 196, pl. 15, figs. 5a-c.

This species is known only from the imperfect specimen first described and figured by Matthew, as noted above, in 1886. An examination of this specimen, which was loaned by the University of Toronto with the other types of bivalved Crustacea described by Matthew, shows that it is in good condition except for a strip along the hinge which is broken away. The outline seems to have been somewhat elongate elliptical, the surface rather strongly convex, the edge rounded inward, and the test thin, noncalcareous, polished, and distinctly punctated. These features remove the species from *Primitia* and point strongly to *Indiana*. Further, assuming that the missing part is only that immediately adjacent to the hinge line, it is inferred that the specimen is a left valve of a species of this genus closely allied to *I. secunda*, *I. dermatoides*, and *I. suberecta*. A perfect specimen might possibly prove identical with one of these species, but so far as it goes, the imperfect type of *I. ? acadica* can not be exactly correlated with the supposed corresponding parts of any described species. Still, it should be confessed that this assertion is based chiefly on the conviction that the part missing from the specimen is not, as Matthew thought, merely the antero-cardinal part, but that it includes the whole of a short hinge, and that the line of fracture is approximately parallel to the removed dorsal edge. If this supposition is correct, then the species must be one of the strongly oblique forms with a broadly rounded posterior margin, like *I. dermatoides* and *I. suberecta*. In the matter of size, *I. ? acadica* agrees much better with *I. secunda* than with the other species referred to in these remarks.

As the injury to the type specimen has removed the back and cardinal angles, which parts afford the most diagnostic specific characters of *Indiana* and allied genera, it may never be possible to identify the species beyond question. However, a feature not observed

in other forms may serve as a satisfactory clue. This is a slightly depressed, very minutely granular circular spot, situated near the middle of the valve. This probably represents the external aspect of a muscle spot corresponding to a similarly located smooth spot observed in internal casts of *I. primaeva* (?Matthew) Ulrich and Bassler and *Bradoria steadyi* (Matthew).

Occurrence.—Middle Cambrian (Acadian, division C1c1), Porter's Brook, St. Martins, New Brunswick.

INDIANA? MINIMA Wiman

Plate 9, Figure 14

Indiana? minima WIMAN, Bull. Geol. Inst. Upsala, vol. 6, pt. 1, 1902, p. 48, pl. 1, figs. 38, 39.

Wiman's figures of this doubtful species are reproduced on Plate 9. Judging solely from these figures and the original description, it seems highly improbable that the species really belongs to *Indiana*, or indeed to any established genus of Cambrian bivalved Crustacea. Its small size and elliptical form suggests Ostracoda like *Cytherella* and *Bythocypris*, but the fact that its shell is "chitinous, black and polished," probably precludes all likelihood of genetic relationship to such later Crustacea. In the character of its test it appears to agree with the majority of the Cambrian bivalves treated in this work. Though *Indiana* affords perhaps as good a temporary lodgment for the species as any known genus, it must finally be removed on account of the strong convexity of the dorsal side of the outline. In all true species of *Indiana* the back is straight. In size, too, they greatly excel *I. minima*, the length of the latter being only about 1.1 mm.

Occurrence.—Drifted glauconite sandstone, Åland, Sweden. Probably Middle Cambrian.

INDIANA? SOLVENSIS (Jones)

Plate 9, Figure 29

Leperditia solvensis JONES, Ann. Mag. Nat. Hist., ser. 2, vol. 17, 1856, p. 95, pl. 7, fig. 15.—SALTER, Proc. Geol. Soc. London, vol. 20, 1864, p. 238.

Primitia solvensis JONES and HOLL, Ann. Mag. Nat. Hist., ser. 4, vol. 2, 1868, p. 55 (footnote).

Assuming that the original type of this species is really of Cambrian age, and being convinced that true Leperditidae were not developed before the close of the Ozarkian period, it is deemed advisable to refer it to the Cambrian genus most suggested by the meager description and figure published by Jones. According to the latter, a copy of which is given on Plate 9, it seems to agree best with species of *Indiana*, the outline suggesting *I. lippa* rather more than any of the others. Jones describes the ends and ventral margin as having "a well defined, flattened, marginal rim," a feature that, while unusual

in *Indiana*, is yet occasionally observed in American species of the genus (for instance, *I. labiosa*).

Occurrence.—The type specimen is said to be an “impression of the outside of a small (right) valve” one-eighth of an inch in length and but slightly convex, found in the basal part of the Llandeilo Flags of South Wales, at Upper Solva, Solva Harbour, St. Davids. Hicks subsequently gives the horizon as the Menevian Paradoxides bed.

INDIANA? CAMBRENSIS (Hicks)

Plate 9, Figure 18

Leperditia cambrensis HICKS, Quart. Journ. Geol. Soc. London, vol. 27, 1871, p. 401, pl. 15, figs. 15–17.—ETHERIDGE, Mem. Geol. Surv. Gt. Britain, vol. ed. 2, 1881, p. 487.

This species is removed from *Leperditia* to *Indiana* for reasons practically the same as those inducing a similar course with respect to *L. solvensis* Jones. As in that case, the species is known only from poor figures and quite inadequate remarks. The specimens are said to much distorted by pressure, and the figures (reproduced on Plate 9) vary so greatly that, with the evidence now available, it is impossible to decide as to the specific relations of the species. Jones, who saw the specimens, regarded them “as undeterminable.”⁸ If figure 15 is approximately like the normal form it would be a close ally of *I. lippa*. The other two specimens are probably of a different type. Both recall another Cambrian species from the same locality subsequently described by Jones as *Leperditia hicksii*. The latter is here referred tentatively to *Bradoria*.

Occurrence.—Red shales in lower part of the “Longmynd group,” Lower or Middle Cambrian, St. Davids, South Wales.

INDIANA LENTIFORMIS (Cobbold)

Plate 9, Figure 30

Leperditia? lentiformis COBBOLD, Quart. Journ. Geol. Soc., vol. 96, 1921, p. 367, pl. 24, figs. 46 a–c.

Diagnosis.—General outline bean shaped; anterior end shortly truncate; dorsal border gently convex for about two-thirds of the total length, then bending more rapidly and passing to the posterior rounded end in a line that is almost straight; ventral border one long fairly regular curve from the truncate anterior to the posterior end; surfaces of both valves regularly convex, except near the anterior end, where there is a short ill-defined depression passing obliquely towards the ventral border; test thin, corneous, having the surface marked by a network of impressed lines, the interspaces being convex, and more or less elongate and parallel with the border.

⁸ Quart. Journ. Geol. Soc. London, vol. 28, 1872, p. 154.

Dimensions.—Length = 11.5 mm.; depth = 7 mm.; thickness of the two valves together = 4 mm. (Cobbold, 1921.)

Although apparently a valid species of *Indiana*, *Leperditia lenti-formis* is unusual in the large size of its carapace.

Occurrence.—Lower Cambrian, Olenellus limestone: Comley, Shropshire, England.

DIELYMELLA, new genus

Description.—Carapace bivalved, 5 to 10 mm. long; outlines pod shaped in lateral view, acutely elliptical in edge views, thickest in the anterior half; valves not closing tightly, leaving a narrow gap that extends from the anterior extremity of the hinge around the ventral edge and through the postdorsal region; gap usually narrowest in the ventral part and widest about the middle of the posterior side; anterior extremity truncated, forming an angle of 90° or less with the hinge line; the antero-dorsal extremity generally beaklike, suggesting the rostrum of a pelecypod but not projecting above the hinge line; posterior outline strongly rounded, ventral edge more gently convex; hinge line long, straight. Surface of valves moderately convex, slight posteriorly but gradually rising toward the umbo. Test thin, in color and probably chemical composition like that of a linguloid brachiopod; surface smooth or finely punctate. Interior of valve with a minute elevation in the rostral cavity which is indicated in the cast by a corresponding depression. Usually an obscure fold extends downward from this elevation and parallels the anterior margin.

Genotype.—*Dielymella recticardinalis*, new species.

Like *Walcottella*, most of the known species of this new genus of bivalved crustacea occur in the Bright Angel shale of the Grand Canyon. While the species of the two genera are not all associated, it is yet a fact that common occurrences prove them all to belong to essentially the same bed. Only *D. recticardinalis* is confined to a single locality at which no species of *Walcottella* has been recognized, but with it occur *D. appressa* and *D. nasuta*, both of which seem to be abundant at the Bass Canyon locality from which most of the *Walcottellas* were procured.

Respecting the systematic position of *Dielymella*, it is thought to be with *Indiana* Matthew on the one hand, and an unquestioned Phyllocarida like the Ordovician *Caryocaris* and the Devonian *Elymocarid*, on the other. Of course there is a wide structural interval between these two extremes, but *D. recticardinalis*, especially the variety *angustata*, seems to fairly represent an intermediate stage. These Cambrian bivalved crustacea are in a way synthetic, their modifications tending generally in two directions, one toward the leperditoid Ostracoda, the other toward the ceratiocarid Phyllopora. *Dielymella* illustrates a modification toward the latter type, while *Indiana* and

certain species of *Walcottella* trend in the opposite direction toward the Leperditian type. Neither is believed to be a link in a true genetic chain, and the latter is probably merely prophetic or suggestive of a subsequent evolutionary departure from the same synthetic stock that finally culminated in the Leperditiidae. In the case of *Dielymella*, this is probably only an abortive expression of the tendency of the old stock to modify in the direction of the ceratiocarid carapace, since the true line of the latter had been established already in middle and early Cambrian times.

The small impressions in the umbonal part of the casts of the interior, satisfactorily seen only in the genotype, are thought to be comparable in a broad way to the impressions of the rostral clavicles and muscles seen in the Ordovician bivalved crustacean genera *Technophorus* and *Ischyрина*.⁹ These pelecypodlike shells are related to *Ribeiria* and similar types of presumed crustacea occurring in the rocks of Beekmantown and Ozarkian ages, which in part close the obvious gap between *Technophorus* and *Dielymella*.

Considering generic characters, *Dielymella* is distinguished from *Indiana* by the greater development and more prowlike shape of the anterior part and the wider gape of the valves. In that genus the antero-cardinal angle is generally rounded off and never beaklike, as it commonly is in *Dielymella*.

DIELYMELLA RECTICARDINALIS, new species

Plate 10, Figures 3-7

Description.—Carapace podlike, the greatest height and length respectively as 7 or 8 is to 12; hinge line long, straight, terminating abruptly at the truncated anterior extremity, but passing gradually into the curve of the posterior extremity; antero-cardinal angle obtusely beaklike, the angle of the anterior and cardinal sides approximately 90°; remainder of outline curved, the posterior part narrowly, with the most prominent point above the mid-height, the ventral part a more or less nearly regular elliptic curve. Commonly a slight increase in rate of curvature is noted in the antero-ventral part. Valves moderately convex, without nodes of any kind, the highest point somewhat above and slightly in front of the middle; edge usually simple; but some valves exhibit a narrow band along the ventral margin, probably due to a delicate, raised line on the inner surface and a slight marginal thickening of the inner edge; anterior and dorsal slopes of casts of the interior usually increasing suddenly just before reaching the edge, this fact causing a bluntness not

⁹ These genera have been described as pelecypoda. The doubt as to the systematic position of these shells raised by Ulrich in 1894 (*The Lower Silurian Lamellibranchiata of Minnesota*, p. 613) has been strengthened by further study, so that it is now regarded as practically settled that they are bivalved crustacea and not Pelecypoda.

observed at the posterior edge, and at least less evident on the ventral side. Gape of valves narrow, nearly uniform in width in the anterior and ventral parts, but expanding slightly in the posterior. Most of gape made up by the right valve. Test thin, black to light gray, usually exfoliated, the outer surface rarely seen, distinctly punctate when preserved.

Dimensions of rather large example: Greatest length, 10.0 mm.; greatest height, 6.2 mm.; greatest thickness of single valve, about 2.0 mm.; of entire carapace, about 4.2 mm.

By far the most of the specimens studied retain both valves, which, considering the coarseness of the sandy matrix, probably indicates a strong hingement of the valves. As the hinge is not denticulated, and as the valves are not kept in place by overlap of their edges, it is assumed that comparatively strong muscles, probably located in the umbonal part, were responsible for their retention in place. The small depressions in the casts of the antero-dorsal angle are thought to indicate the lodgment of these muscles.

Occurrence.—Common in the Bright Angel shale, head of Nunkoweap Valley, Grand Canyon of the Colorado, Ariz. *D. nasuta* and *D. appressa* are comparatively rare at the same locality, but species of *Walcottella* were not observed.

Cotypes.—Cat. No. 56510, U.S.N.M.

DIELYMELLA RECTICARDINALIS ANGUSTATA, new variety

Plate 10, Figure 8

The interior cast of an entire carapace figured on Plate 10 is all that has been seen of this variety. It is considerably smaller than the average for specimens of the typical form of the species. That it is not merely a young stage of the typical variety is demonstrated by the figure of a smaller individual of the latter beside it on the same plate. (Fig. 7.) In the absence of other specimens, the writers hesitate to separate the individual under discussion as a distinct species, the subordinate designation above proposed being thought provisionally sufficient to cover the case.

On comparison the variety *angustata* is readily distinguished by its more elongate form, the length (7.0 mm.) being fully twice the height (3.5 mm.) whereas in the typical variety the height scarcely exceeds two-thirds of the length. In the former the anteroventral part of the outline is less prominent, the recession of the curve beginning nearer the dorsal angle. The posterior end also is somewhat different, the point at which the outline bends forward being opposite the mid-height, instead of above it. All of these peculiarities might have been produced by accidental compression of the ventral half of the carapace; but as the specimen exhibits no evidence of such distortion, indeed, as none of the fossils from this bed seem to have suffered

appreciably from pressure, the suggested possible cause of the differences is discredited.

Occurrence.—Same as the preceding.

Holotype.—Cat. No. 56511, U.S.N.M.

DIELYMELLA NASUTA, new species

Plate 10, Figures 10, 11

Description.—Carapace somewhat obliquely acuminate ovate, the greatest height equaling about two-thirds the length; hinge straight, long, its extremities sharply defined, the posterior angle about 120° , the anterior less than 90° , prominent, obtusely claw-shaped; anterior end narrower than the posterior, straight or very gently concave in the upper half; the remainder of outline, from middle of anterior side to posterior extremity of hinge, a nearly regular elliptical curve, the narrowest part of which corresponds to the postventral margin. Valves strongly convex, attaining greatest thickness in anterior half; no border. Surface of shell usually appearing smooth but when well preserved exhibits minute and irregularly arranged punctae.

Dimensions of best specimen, a left valve, apparently of average size: Greatest horizontal length, 7.7 mm., length diagonally across valve from beak to postventral margin, 8.3 mm.; greatest height (just behind middle) 5.9 mm.; greatest thickness, single valve, about 2.7 mm.

Remarks.—In this species the anterior extremity is even more acuminate and beaklike than in *D. reticardinalis*. It differs from that species further in being proportionately much wider posteriorly and narrower anteriorly, in the more definite angularity of the postcardinal margin, and in being relatively shorter. All these differences apply again in comparing it with *D. appressa*, with the additional fact that the latter is less convex.

Occurrence.—Bright Angel shale. Bass Canyon and head of Nunkoweap Valley, Grand Canyon of the Colorado, Ariz.

Cotypes.—Cat. Nos. 56508, 56509, U.S.N.M.

DIELYMELLA APPRESSA, new species

Plate 10, Figure 9

Description.—Disregarding the truncation of the hinge line and the rectangular antero-cardinal region, the outline is elongate elliptical. The valves are compressed convex, the middle third of the profile, in a dorsal view, almost straight. Surface of test obscurely punctate or smooth; irregularly striated along the free margin.

Dimensions of a large carapace: Greatest length, 9.4 mm.; greatest height, 5.5 mm.; greatest thickness, 2.3 to 3.0 mm.

Remarks.—This species is easily separated from *D. reticardinalis* being less convex, wider posteriorly, and less prominent in the antero-

cardinal region. The surface of test also is less distinctly punctate or quite smooth, though this difference is not usually apparent, the shell being usually exfoliated. Young specimens resemble *D. dorsalis*, but the posterior margin is more uniformly curved. *D. nasuta* is more convex and its anterior extremity quite different in shape.

Occurrence.—Bright Angel shale; three specimens found associated with *D. reticardinalis* at head of Nunkoweap Valley, seven specimens at the Bass Canyon locality with numerous examples of *Walcottella*; Grand Canyon of the Colorado, Ariz.

Holotype.—Cat. No. 56506, U.S.N.M.

DIELYMELLA DORSALIS, new species

Plate 10, Figure 1

Description.—Carapace oblong, subquadrate, the ends nearly equal, the posterior slightly the wider and its outline most prominent in the dorsal half; hinge line very long, terminating abruptly at the rectangular front, postcardinal angle sharply rounded; ventral half of outline semielliptical. Surface of valves moderately convex with an obscure flattening in the mesial third of the dorsal half. An obscure elevation or node occurs near the antero-dorsal angle in the type specimen; but as it is slightly injured at this point, it is not possible to decide whether the node is a natural feature or accidental. Test somewhat exfoliated, apparently smooth.

Dimensions of a right valve: Greatest length, 4.2 mm.; height, 3.0 mm.; thickness, about 0.75 mm.

Remarks.—Unfortunately the unique example on which this species is founded is not quite perfect. As interpreted it is a right valve. Whether a right or a left, it is certain that the postdorsal part of its outline is more abruptly rounded and more produced than in any of the other species referred to this genus. Except in this respect, *D. dorsalis* is sufficiently like young examples of *D. appressa* to necessitate care in their discrimination. The flattening of the centrodorsal region, on the other hand, is so suggestive of the associated *Indiana impressa* that it is difficult to distinguish specimens with imperfect margins. Good specimens, of course, offer no difficulties, the dorsal half of the outline being quite different in the two species.

Occurrence.—Bright Angel shale, Bass Canyon, Grand Canyon, Ariz.

Holotype.—Cat. No. 56505, U.S.N.M.

DIELYMELLA BREVIS, new species

Plate 10, Figures 12, 13

Nothozoe? vermontana (part) WALCOTT, 10th Ann. Rep. U. S. Geol. Surv., 1890, pl. 80, figs. 4a, 4b (not fig. 4).

Not *Nothozoe vermontana* WHITFIELD, Bull. Amer. Mus. Nat. Hist., vol. 1, 1884, p. 414, pl. 14, figs. 14, 15.

Description.—Carapace large, relatively short, compressed convex; outline, excepting the antero-dorsal angle and the straight hinge, nearly circular; height a little less than four-fifths the greatest length, postdorsal angle very obtuse, anterior angle sharply defined, 85° to 90° ; hinge line straight, its length nearly equaling the greatest height of carapace; anterior margin approximately straight and nearly vertical in the upper two thirds. Valves moderately convex, thickest in the antero-dorsal half in which part the slope to the outer edges is less gentle than toward the ventral and posterior sides. Test unknown, replaced in the specimens by a ferruginous coating of the interior cast.

Dimensions: Length 17.1 mm.; height, 14.2 mm.; length of hinge, 13.5 mm. Other specimens referred to this species range in length between 8 and 12 mm.

Remarks.—This species is founded chiefly on two opposite valves, both of which were somewhat poorly illustrated by Walcott and referred by him¹⁰ to *Nothozoe vermontana* Whitfield. New figures, based on photographic prints of the originals, have been prepared for this work. Comparing these with Whitfield's figures of *N. vermontana*, it will be observed that the former are quite different from the latter, especially in the outline of the dorsal half.

While there is considerable reason for the retention of Whitfield's original specimens under *Nothozoe*, a similar course in the case of the specimens above described is manifestly unjustifiable. Their reference to *Dielymella*, though not entirely satisfactory, is yet within the range of a reasonable extension of the boundaries of this genus. The dominant external characteristics of the carapace of *Dielymella* such as the rectangular form of the antero-dorsal part of the outline, the straight hinge, the general curvature of the posterior margin, and the fullness of the anterior part of the surface, are all present in *D. brevis*. The habitat of *D. brevis* also seems to have been the same as that of all other species of the genus. It occurs in a coarse, quartzitic sandstone lithologically very similar to the bed of sandstone from which the preceding Arizona species were procured.

Compared with other species of *Dielymella*, apparently the principal and only striking difference is in a feature that, under ordinary circumstances, can not be given a greater significance than specific, namely, in the matter of relative length, this being greatly less in *D. brevis* than in the other forms referred to the genus.

Occurrence.—From a boulder of quartzite found on Sunset Hill, near Lake Dunmore, Salisbury, Vt., and presumably derived from nearby Lower Cambrian ledges.

Cotypes.—Cat. No. 56504, U.S.N.M.

¹⁰ 10th Ann. Rept. U. S. Geol. Surv., 1890, pl. 80, figs. 4a, 4b.

MONONOTELLA, new genus

Primitia? (part) MATTHEW, Trans. New York Acad. Sci., vol. 14, 1895, p. 137.
Indiana (part) MATTHEW, Canadian Rec. Sci., vol. 8, 1902, p. 461.

Description.—Carapace small, consisting of a single plate bent sharply along the back till the edges are brought nearly together at the ventral side, or possibly of two valves ankylosed along their dorsal edges; ends, especially the posterior, gaping rather widely; subfusiform in a lateral view, broadly rounded posteriorly and tapering anteriorly to an obtusely acuminate extremity; acuminate ovate in a dorsal view; sides strongly convex, without nodes of any kind. Test as in *Indiana*, black, thin, pliable, minutely punctate.

Genotype.—*Mononotella fusiformis* (*Primitia? fusiformis* Matthew).

Remarks.—But a single species having the characters ascribed to this new genus has been observed. This was described in 1895 by Matthew¹¹ under the name *Primitia? fusiformis*. In 1902¹² the same author referred the species to his genus *Indiana*. The generic characters are taken from a nearly complete though somewhat crushed example in the United States National Museum, which was carefully compared and specifically identified with Matthew's original type of the species.

The most important addition to the knowledge of this species brought out by the study of the specimens in the National Museum is the apparent fact that its carapace, instead of being formed of two loosely hinged valves, as in the otherwise not very dissimilar species of *Indiana*, consists either of firmly united (ankylosed) valves or of a single plate bent so as to simulate the bivalved forms. The fact that the dorsal part of the test in the best specimen is not entire but shows a line of fracture leaves the matter of its supposed original unity still somewhat doubtful. However, the ragged nature of the line is regarded as strongly indicative of separation by fracture. It certainly differs from the usual appearance of the line dividing the dorsal edges of the valves in ordinary bivalved forms.

Aside from the supposed dorsal ankylosis of the valves, the carapace of *Mononotella* is not greatly different from that of *Indiana*. The gap between the incurved edges at the ends and the ventral side is much wider, and this doubtless is a valid generic character. The much greater anterior type is a conspicuous peculiarity, but as only a single species of *Mononotella* is known and as the form of the carapace is subject to considerable variation in different species of most genera of bivalved crustacea, it is impossible as yet to decide as to the degree of importance that should be ascribed to the difference.

None of the other genera of Cambrian Crustacea described in this work is closely allied. The British *Hymenocaris*, which has a folded,

¹¹ Trans. New York Acad. Sci., vol. 14, 1895, p. 137, pl. 8, figs. 3a, 3b.

¹² Canadian Rec. Sci., vol. 8, 1902, p. 461.

univalved carapace, possibly is not far removed, but the general aspect of its known parts differs so greatly from the present genus that anything like close affinities between the two seems highly improbable. While *Hymenocaris* is generally and probably correctly regarded as an early representative of the Phyllocarida, no such relation is believed to fit the case of *Mononotella*. This genus, on the contrary, seems too much like *Indiana* and its more immediate allies to permit of wide separation; hence, like those genera, its systematic position is believed to be with the Phyllopoda and nearer the Ostracoda than the Phyllocarida.

MONONOTELLA FUSIFORMIS (Matthew)

Plate 8, Figures 22-25

Primitia(?) fusiformis MATTHEW, Trans. New York Acad. Sci., vol. 14, 1895, p. 137, pl. 8, figures 3a, 3b.

Indiana fusiformis MATTHEW, Canadian Rec. Sci., vol. 8, 1902, p. 461.

Description.—Carapace oblique, acuminate-ovate in lateral view, the anterior end tapering to an obtuse point, the posterior half comparatively broadly rounded, semielliptic, the post dorsal angle obtuse but causing an appreciable angulation about the middle of the dorsal half of the outline; dorsum nearly straight; ventral part of outline very gently convex until it begins to turn rapidly upward around the posterior end. Sides (?valves) strongly convex, turned inward along the edges; gap wide at the ends, especially so at the posterior, narrowing from either end toward the middle of the ventral side. Test thin, black, minutely punctate; punctae rather closely arranged, but not sufficiently so to suggest reticulation.

Dimensions of a nearly complete carapace: Greatest length about 7.0 mm., greatest width (at right angles to greatest length) 4.0 mm., greatest thickness about 4.0 mm.

Remarks.—The single example (a left valve) of this species in the Matthew collection of types is so different in its outline from all the other Cambrian Conchostraca that it was recognized at once. The narrower and almost acute anterior extremity characterizing the species, while not perfectly preserved in the type specimen, is yet very nearly complete. From this species alone it was not possible to decide as to which is the ventral and which the dorsal side. Matthew referred to it somewhat doubtfully as a right valve, but on comparison with a more complete carapace, it proved to be a left side. Matthew based his view chiefly on what he took to be obscure eye tubercles, and a shallow groove running from them two-thirds across the valve. He noted further a filiform fold at the posterior margin. None of these features, however, is believed to be normal. On the contrary, they are thought to have been effected by accidental distortion of the pliable test. Similar fortuitous elevations and grooves are common

in specimens of otherwise very different Cambrian species studied in the course of this work.

Occurrence.—Lower Cambrian (Hanfordian, division C1b3). Matthew's type is from Hanford Brook, St. John County, New Brunswick. Specimens in the United States National Museum are from the same locality and probably from the same beds. A single example (E3b), doubtfully referred to the species, came from the Etcheminian at Dugald Brook, Cape Breton, Nova Scotia.

Plesiotype.—Cat. No. 56499, U.S.N.M.

Family LIMNADIIDAE Baird

Genus LEPIDITTA Matthew

Lepiditta MATTHEW, Trans. Royal Soc. Canada, vol. 3, sec. 4, 1886, p. 61.—MILLER, North Amer. Geol. and Pal., 1889, p. 553.—MATTHEW, Trans. New York Acad. Sci., vol. 15, 1896, p. 194.

Description.—Carapace small, a millimeter or two in length bivalved, obliquely semielliptical or semicircular, narrow and more or less acuminate posteriorly, wider and nearly rectangular anteriorly, with the hinge straight and extending the full length of the valves. Surface moderately convex, usually with a low, conical, umbonelike elevation near or in front of the middle of the dorsal edge. Test thin, composition doubtful, probably calcareous; externally marked with concentric lines or undulations and sometimes with minute radial lines rarely smooth. Casts of the interior exhibit a short, vertical fissure or depression suggesting a clavicle on inner side of shell.

Genotype.—*Lepiditta alata* Matthew. Middle Cambrian.

Remarks.—The systematic position of this genus is somewhat doubtful. The shell being usually dissolved away in the shales, it is thought likely to have been more calcareous than in the great majority of Cambrian bivalved Crustacea. In this respect then it would appear to agree with *Fordilla* in which the shell is known to be highly calcareous. It agrees further with that genus in presenting an aspect simulating that of a minute pelecypod. These peculiarities suggest the phyllopod genus *Estheria* more than any other bivalved crustacean known, and the resemblance is believed to be sufficient to warrant the provisional reference of these two Cambrian genera to the Limnadiidae. The principal objection to this arrangement lies in the fact that Crustacea like *Estheria* are almost if not entirely unknown in rocks older than Devonian. A possible exception is *Orthonotella faberi* Miller, described as a pelecypod, which is found in the upper part of the Ordovician at Cincinnati, Ohio. Other possible exceptions are *Ischyrina* and *Technophorus*, both founded on Ordovician species hitherto referred to the Pelecypoda.

The separated valves of the Middle Devonian genus *Schizodiscus* Clarke agree so closely with those of *Lepiditta* that it is really difficult

to point out satisfactory differences. The carapace of *Schizodiscus*, however, is supposed to be peltate, while in *Lepiditta* the two valves are thought to have closed as in *Estheria*. Compared further with the latter genus *Lepiditta* differs in the form of its valves, these being much narrower and subacuminate instead of rounded, posteriorly; and the concentric markings of the shell are less regular and not ridgelike. The small interior clavicle in front of the umbones is an interesting reminder of a similar feature in *Ribeiria*, *Ischyрина*, and *Technophorus*.

Only two of the four species referred to this genus by Matthew are regarded as strictly belonging here. These are his *L. alata* and *L. curta*. The other two, *L. auriculata* and *L. sigillata*, are each represented by a single example that in neither case is sufficiently good to encourage an attempt at final classification. Provisionally they must be viewed as doubtful species.

A possible third good species is indicated by Steusloff's *Bythocypris polita*. As figured and described, this species agrees very well with *L. alata* in general aspect, but differs in its smooth, polished shell and in the unusual abruptness of the ventral slope. As it is most certainly not a *Bythocypris*, it is removed provisionally to *Lepiditta*.

LEPIDITTA ALATA Matthew

Plate 7, Figures 24, 25

Lepiditta alata MATTHEWS, Trans. Royal Soc. Canada, vol. 3, sec. 4, 1886, p. 61, pl. 6, figs. 16, 16a; Trans. New York Acad. Sci., vol. 15, 1896, p. 194, pl. 15, figs. 1a, 1b.

Description.—Valves obliquely semielliptical, broad and rectangular on the anterior side, narrowing posteriorly; hinge straight, extending the full length of valves. Surface moderately convex, marked by numerous, rather regular but not very sharply defined concentric lines. These center at the small umbonal elevation which is located just within the dorsal edge and approximately one-third of the length of the hinge behind the anterior angle. Very delicate lines radiating from the umbo observed on a cast of the exterior. In casts of the interior the umbo is more prominent than on the exterior and the clavicle causes a small, sharp, sometimes fissurelike, vertical depression just in front of it.

Dimensions: Length, 1.15 mm.; greatest height 0.89 mm.

Remarks.—The above description is based on the specimens selected by Matthew as the types of his species. Except that they do not preserve the test, they are in good condition; and being molds of the two surfaces of the shell, internal characters are seen that are not usually visible. One of the molds of the exterior surface shows two obscure radial ridges disposed somewhat as in the Pennsylvanian *Lecia leidyi*. Although these obscure radial ridges are to be observed

on most of the specimens, they are not mentioned in the description because there is ground for the suspicion, if not the conviction, that they are at least in part due to compression.

Occurrence.—Middle Cambrian (Acadian): In the fine gray shales of division C1c2 of Matthew's section at Hanford Brook, St. Martins, New Brunswick.

LEPIDITTA CURTA Matthew

Plate 5, Figures 18, 19, Plate 7, Figure 29

Lepiditta curta MATTHEW, Trans. Royal Soc. Canada, vol. 3, sec. 4, 1886, p. 62, pl. 6, fig. 17; Trans New York Acad. Sci., vol. 15, 1896, p. 195, pl. 15, fig. 2.

Description.—Valves obliquely semielliptical or subtriangular, with the length and height, respectively, about as 10 is to 7; hinge straight, the remainder of the outline rather gently curved except at the antero-ventral angle, where it is sufficiently rapid to suggest the word triangular in speaking of the outline. Surface now depressed convex, originally probably rather strongly convex, marked with five or six unequal concentric undulations. Umbo inconspicuous, situated about one-fourth of the length of the hinge line behind the front angle.

Dimensions: Length, 1.50 mm.; height, 1.02 mm.

Remarks.—Only the two specimens marked by Matthew as the types of the species have been seen. Matthew speaks of the interior of the shell as having "roughened zones or undulations concentric to the umbo." As the types retain very little of the shell and are merely impressions of the exterior slightly roughened by remains of the decomposed shell, the observation applies to the exterior rather than to the interior. Respecting the affinities of the species, there can be no reasonable doubt of its close relations to *L. alata*. So far as shown by the specimens, it differs from that species only in being a little larger, relatively shorter and more triangular in shape and in having fewer and coarser concentric undulations of the surface. Radial lines, aside from those due to compression, are very obscurely indicated.

Occurrence.—Middle Cambrian (Acadian): In the fine dark shales of division C1d of Matthew's section at Porters Brook, St. Martins, New Brunswick.

LEPIDITTA? POLITA (Steusloff)

Plate 7, Figure 28

Bythocypris polita STEUSLOFF, Zeits. d. d. geol. Gesell., vol. 46, 1894, p. 775, pl. 58, fig. 31.

This species is known only from the description and figures published by Steusloff. Judging from these the valves are obliquely semielliptical, the anterior side descending rectangularly from the long, straight hinge, the posterior side narrower and relatively acuminate at the dorsal angle. Near the middle of the dorsal edge, two widely diverg-

ing, linear depressions outline a low, umbonelike elevation. The surface is smooth and polished and slopes more abruptly to the ventral and anterior edges than to the dorsal and posterior margins. The length is given as 0.8 mm., the height as 0.4 mm.

Occurrence.—Limestone probably Middle Cambrian in age, containing besides *Acrothele* species and *Parabolina* species. Drift, Neue Brandenberg, Germany.

DOUBTFUL SPECIES

LEPIDITTA? AURICULATA Matthew

Plate 5, Figure 20, Plate 7, Figure 26

Lepiditta auriculata MATTHEW, Trans. Royal Soc. Canada, vol. 11, sec. 4, 1894, p. 99, pl. 17, figs. 2a, b; Trans. New York Acad. Sci., vol. 15, 1896, p. 196, pl. 15, figs. 3a, 3b.

The type of this species is most certainly not a congener of the two preceding typical species of *Lepiditta*. Indeed, it is thought highly improbable that it is a bivalved crustacean at all. Its mode of preservation and general appearance is the same as that of the associated trilobites, while the form, and especially the symmetrically bilateral arrangement of its parts, suggests nothing else so much as the hypostoma of some trilobite.

Matthew calls it a left valve and speaks of "two grooves in the mold at the hinge line showing that the hinge had two oblique plates or teeth towards the posterior end." The grounds for determining it to be a left valve and not a right are not stated, and close examination has failed to show anything even suggesting such a thing as the supposed hinge teeth.

Occurrence.—Middle Cambrian (Acadian). In division C1c1 of Matthew's section at Hanford Brook, New Brunswick.

LEPIDITTA? SIGILLATA Matthew

Plate 5, Figure 21; Plate 7, Figure 27

Lepiditta sigillata MATTHEW, Trans. Royal Soc. Canada, vol. 11, sec. 4, 1894, p. 98, pl. 17, fig. 1; Trans. New York Acad. Sci., vol. 14, 1895, p. 138, pl. 8, fig. 8.

The type and only known representative of this species, while unquestionably one side of a bivalved crustacean, seems no less certainly not congeneric with *L. alata*. The present shape of the specimen is much like that of a true *Lepiditta*, but after a careful investigation the conclusion that it resulted through distortion of the dorsal part seemed inevitable. The ventral part of the specimen apparently was not greatly affected, but the back has been crushed and turned in on itself—a condition that, considering the pliability of the test in most of these Cambrian bivalves, is not at all extraordinary. Many

similar instances of partial distortion were observed in the course of these studies. Matthew's statement concerning a "narrow, oblique tooth or ridge inside the shell at the hinge line" proves to be based on a crumpling of the test at this point and not on a structural feature of the hinge. The marking of the surface by "two diverging rows of shallow impressions" and the "small round tubercles" seem both to be somewhat fanciful interpretations of what are believed to be merely accidental indentations of the inner and outer surfaces of the test by grains of sand.

The composition of the test is not the same as in true *Lepiditta* but agrees essentially with that of the shell of *Bradoria* and *Beyrichona*. Being convinced that the dorsal half of the type of *L. sigillata* has been crushed almost out of existence, a comparison of the remaining ventral half with corresponding parts of species of *Bradoria* and *Beyrichona* brought out the fact that in at least one of the species of the latter genus, namely, *Beyrichona planata*, the lower half of the valve corresponds exactly with the specimen under discussion. The probability thus suggested may be satisfactorily tested by covering, somewhat obliquely, the upper part of Figure 4 on Plate 6, and comparing the remaining portion with the enlarged photograph of *L. sigillata* on Plate 7. In corroboration it remains to be said that *L. sigillata* came from the same stratigraphic division, if not the same layer, as *B. planata*.

Occurrence.—Lower Cambrian (Hanfordian, division C1b3); Hanford Brook, New Brunswick.

Genus FORDILLA Walcott

Fordilla WALCOTT, Bull. U. S. Geol. Surv., No. 30, 1886, p. 123.—MILLER North Amer. Geol. and Pal., 1889, p. 480.

Although closely resembling a pelecypod in outline, the interesting species upon which *Fordilla* is based has the calcareo-phosphatic structure of genera here referred to the Limnadiidae. The type species has been described in detail by various authors and we have noted our idea of its relationships in the discussion of *Lepiditta*.

Genotype.—*Fordilla troyensis* Barrande. Lower Cambrian.

FORDILLA TROYENSIS Barrande

Plate 4, Figures 14, 15

Fordilla troyensis BARRANDE, Acepheles: Ext. Syst. Sil. du Centre Boheme, 1881, Expl. pl. 361.—WALCOTT, Bull. U. S. Geol. Surv., No. 30, 1886, p. 125, pl. 11, figs. 3, 3a-c; Amer. Jour. Sci., ser. 3, vol. 34, 1887, p. 192.—SHALER and FOERSTE, Bull. Mus. Comp. Zool., No. 16, 1888, p. 29, pl. 1, fig. 4.—LESLEY, Geol. Surv. Pa. Rept., p. 4, 1889, p. 251, 4 text figs. only.—MILLER, North Amer. Geol. and Pal., 1889, p. 480, text fig. 825.—WALCOTT, Tenth Ann. Rept. U. S. Geol. Surv., 1890, p. 615, pl. 73, figs. 1?, 2, 2a-c.

We have no new observations to add to the description of this species save the remarks as to the classification of the genus given above. *Lepiditta alata*, *Modiolooides prisca*, and the present species seem to us related but in each case more material for study is needed.

Occurrence.—Lower Cambrian, Troy, New York.

Genus MODIOLOIDES Walcott

Modiolooides WALCOTT, Amer. Journ. Sci., ser. 3, vol. 38, 1889, p. 29.

The single specimen representing the genotype and only species of this genus is the cast of a valve which on account of the presence of a muscular scar at the anterior end just within a supposed pallial line caused its reference to the pelecypoda. The shell structure is calcareo-phosphatic as in *Fordilla* and allied genera, so that *Modiolooides* is very probably a crustacean best referred, with present knowledge, to the Limnadiidae.

Genotype.—*Modioloopsis? prisca* Walcott. Lower Cambrian.

MODIOLOIDES PRISCA (Walcott)

Plate 4, Figure 16

Modioloopsis? prisca WALCOTT, Amer. Journ. Sci. Arts, ser. 3, vol. 34, 1887, p. 191, pl. 1, fig. 19.

Modiolooides prisca WALCOTT, Tenth Ann. Rep. U. S. Geol. Surv., 1890, p. 615, pl. 73, fig. 3.

Our unretouched photograph of the type specimen indicates that the oval muscle scar at the supposed anterior end is possibly due to a crushing of the test, a condition very commonly found in the Cambrian Conchostraca. At any rate, more material is necessary before the relations of this interesting fossil can be established.

Occurrence.—Lower Cambrian; Whitehall, Washington County, N. Y.

SPECIES OF UNCERTAIN AFFINITIES

ENTOMIDELLA(?) BUPRESTIS (Salter)

Plate 8, Figures 20, 21

Leperditia buprestis SALTER, British Ass. Rep., Trans. Sec., 1865, p. 285.

Antonis buprestis JONES, Quart. Journ. Geol. Soc. London, vol. 28, 1872, p. 183, pl. 5, fig. 15.

Entomidella buprestis JONES, Ann. and Mag. Nat. Hist., ser. 4, vol. 11, 1873, p. 417.

Leperditia punctatissima SULTI, Siluria, app. 1865, p. 519.

Remarks.—This peculiar species apparently is known as yet only from the specimen originally described by Salter. A photographic reproduction of Jones's figure of this specimen is given on Plate 8. The descriptive remarks published by Salter and later by Jones are in both instances exceedingly unsatisfactory. The valves are represented as "very elongate ovate" but their borders are said to be "partly embedded" in the matrix: and the surface of the "pyritous"

tests is beautifully pitted. Each of the separated valves is crossed by a nearly vertical fracture, marking, according to Jones, a furrow. The length of the valves is about 9.0 mm., the height about 3.0 mm. The type specimen was found in the Menevian at St. Davids, Wales.

This species and *Entomis divisa* Jones were made the genotypes of the new genus *Entomidella* by Jones in 1873, although later he regarded *E. divisa* as the genotype, and still later rejected *Entomidella* as a synonym of *Entomis*. That this Cambrian fossil is really a congener of the Silurian *Entomis* or *Entomidella divisa* seems highly improbable. Throughout his long work on fossil bivalved Crustacea Jones was ever too ready to minimize or overlook highly important discrepancies in structure. Numerous instances illustrating this tendency might be cited. Unfortunately, in the present case, positive data are lacking; but relying on the illustration and meager notes on *E. bupestris* published by Jones, there is strong ground for the suspicion that the Cambrian species is a very different thing from its supposed Silurian congener. That the transverse fracture of the valves of the former represents the long curved furrow of an *Entomis* is especially doubtful. It is thought further that the composition of the test, a factor apparently never considered by Jones, will prove widely different in *E. bupestris* and *E. divisa*. Until an adequate description of *E. bupestris* is published the species must remain among the uncertain forms.

A single valve in the United States National Museum (Cat. No. 56501), apparently somewhat compressed vertically and incomplete at one end, is similar in shape and size to *E. ? bupestris*. It was collected by Doctor Walcott at Hanford Brook, St. John County, New Brunswick, from C1b2 of Matthew's Protolenus zone. Except for the fact that it exhibits no sign of a vertical furrow it might be referred to Salter's species. Possibly it is a distorted and anteriorly incomplete example of *Mononotella fusiformis*, but the parallelism of its dorsal and ventral margins is thought to positively negative that view. For the present it is left unclassified.

Occurrence.—Middle Cambrian (Menevian): St. Davids, Wales. Doubtfully present in the Lower Cambrian (Hanfordian, C1b2) of New Brunswick.

Genus LEPIDILLA Matthew, 1886

Lepidilla MATTHEW, Trans. Royal Soc. Canada, vol. 3, sec. 4, 1886, p. 62.—MILLER, North Amer. Geol. and Pal., 1889, p. 553.

Bivalve? shell having the hinge and body of the valve or plate in different planes. Hinge line straight projecting from the general contour of the shell. Umbo and hinge line separated from the body of the valve by a sinus or emargination behind which is a foramen. (Matthew, 1886.)

Genotype.—*Lepidilla anomla* Matthew. Middle Cambrian.

LEPIDILLA ANOMALA Matthew

Plate 7, Figures 20-23; Plate 5, Figure 17

Lepidilla anomala MATTHEW, Trans. Royal Soc. Canada, vol. 3, sec. 4, 1886, p. 62, pl. 6, figs. 18a-c; vol. 8, 1891, p. 130, pl. 11, fig. 2.

We have refigured the type and only specimen of this species, which is in such a state of preservation that the real affinities can not be determined without a study of additional material. Matthew has brought out the essential features in his generic description, which is copied above.

Occurrence.—Middle Cambrian (Acadian, C1c2): Hanford Brook, New Brunswick.

"LEPERDITIA" VENTRICOSA Matthew

Plate 7, Figure 35

Leperditia ventricosa MATTHEW, Trans. Royal Soc. Canada, vol. 7, sec. 4, 1890, p. 159, pl. 7, figs. 12 a-d; Trans. New York Acad. Sci., vol. 14, 1895, p. 137, pl. 8, figs. 5a-5d.

Isochilina ventricosa MATTHEW, Canadian Rec. Sci., vol. 8, 1902, p. 453.

This species is represented in the Matthew collection of types by two imperfect specimens, one a valve, the other the impression of same or another valve in the hard sandstone matrix. One margin is fairly well preserved and shows a broad, thick flange. The remaining portions of the outline are not in condition to prove that this flange extends around the whole of the free margins, but judging from the general preservation of the specimens, it is thought likely that if it had, more of the flange would have been retained. As preserved the shape is irregularly subovate, the hinge nearly straight, the dorsal angles not very conspicuous. The surface is strongly convex and entirely covered with a network, the meshes of which increase greatly in size toward the middle of the valve, where they are easily visible to the naked eye. The shell is thin, and its composition apparently the same as in *Bradoria* and allied genera. The length is about 8.0 mm., the height about 6.5 mm.

There is nothing about this valve suggesting even remote alliance to *Leperditia*, or to *Isochilina*, as supposed by Matthew. The composition of the valve is as in the Bradoriidae, and hence quite different from the much more calcareous shells of Ostracoda. Obscure tubercles are noted near one of the angles, but they are too indefinite to be compared with those in *Bradoria*. Still, this feature might be waived and the species referred to that genus were it not for the thick anterior (?) flange. Under the circumstances it is thought probable that *L. ventricosa* will finally be referred to an as yet undescribed genus.

The character of the surface ornamentation, especially the fact that the pits, or the meshes of the network, increase in size inward from the margins, seems to be exactly the same as in the even more

obscure "*Leperditia ebenina*" of Dwight. Possibly the two are of the same species, which is not improbable, since they are alike in size. However, their exact relationship can not be established with the evidence now available.

Occurrence.—Lower Cambrian (Hanfordian, division C1b1): Hanford Brook, St. Martin's New Brunswick.

"LEPERDITIA" EBENINA Dwight

Plate 7, Figures 33, 34

Leperditia ebenina DWIGHT, Amer. Journ. Sci., sec. 3, vol. 38, 1889, p. 144, pl. 6, figs. 2-4; Trans. Vassar Bros. Inst., vol. 5, 1890, p. 104, pl. figs. 2-4.

The collection of the United States National Museum contains but a single badly crushed and incomplete example of this species. It was collected by Professor Dwight and presumably belonged to the material on which he based the species. Judging from the figures published by Dwight none of the type specimens is in satisfactory condition. It is represented as transversely subelliptical or semiovate in outline, with a rather long, straight hinge, sharply defined dorsal angles, subequally rounded ends and more gently convex ventral edge. There is some indication of a wide marginal rim and the surface of the valves was probably rather strongly convex. However, in the present flattened condition of the specimens neither of these features is satisfactorily determinable. The most striking characteristic is that the pits of the reticulated surface ornament beginning with very minute sizes along the margins, gradually increase in size toward the middle of the valve, where over a considerable space they are visible to the unassisted eye. This peculiarity is shared by only one other Cambrian species, namely, the scarcely better known *Leperditia?? ventricosa* Matthew. As both are about equal in size, it is not improbable that they represent one and the same species. Until better specimens have been found neither can be regarded as an established species. It is needless to say that they do not belong to *Leperditia*.

Occurrence.—Middle Cambrian, thin bedded limestone, Stissing, Dutchess County, N. Y.

"LEPERDITIA" CAPSELLA Chapman

Plate 10, Figure 17

Leperditia capsella CHAPMAN, Proc. Roy. Soc. Victoria, vol. 31, new ser., pt. 1, 1918, p. 111 pl. 9, fig. 4.

The illustration of this species is included herewith to complete the list of Cambrian forms, although the correct generic position can not be determined at present.

Occurrence.—Upper Cambrian, Archeocyathina limestone: Curramulka, South Australia.

"LEPERDITIA" TATEI Chapman

Plate 10, Figures 14-16

Leperditia tatei CHAPMAN, Proc. Roy. Soc. Victoria, vol. 31, new ser., pt. 1, 1918, p. 109, pl. 9, figs. 1-3.

A reexamination of the type specimens is necessary before the affinities of this species can be determined. Possibly more than one species is represented among the specimens figured.

Occurrence.—Upper Cambrian, Archeocyathina limestone: Curramulka, South Australia.

"LEPERDITIA" cfr. SOLITARIA Barrande

?*Leperditia solitaria* BARRANDE Suppl. Sil. Syst., p. 532, pls. 23, 24 (Etage E).
Leperditia cfr. *solitaria* BURR, Amer. Geol., vol. 25, 1900, p. 47.—GRABAU, Boston Soc. Nat. Hist., Occ. Paper 4, pt. 3, 1900, p. 661.

The above references are inserted to indicate the occurrence of a member of the Conchostraca in Massachusetts, although no illustrations of it have been published.

Occurrence.—Cambrian, North Attleboro, Mass.

"LEPERDITIA" VEXATA Hicks

Leperditia? vexata HICKS, Quart. Journ. Geol. Soc. London, vol. 27, 1872, p. 396.
Larval trilobite? JONES, Quart. Journ. Geol. Soc. London, vol. 28, 1873, p. 184, pl. 5, figs. 17, 18.

The doubt as to the position of this form is indicated in the synonymy.

Occurrence.—Middle Cambrian (Menevian): St. Davids, Wales.

"ISOCHILINA" SWEETI Chapman

Plate 10, Figure 18

Isochilina sweeti CHAPMAN, Proc. Roy. Soc. Victoria, vol. 31, new ser., pt. 1, 1918, p. 111, pl. 9, fig. 5.

The generic affinities of this species, like the preceding, can not be determined without a study of actual specimens.

Occurrence.—Upper Cambrian, Archeocyathina limestone: Curramulka, South Australia.

MODIOLOPSIS THECOIDES Matthew

Plate 1, Figure 34

Modiolopsis thecoides MATTHEW, Bull. Nat. Hist. Soc., New Brunswick, vol. 4, pt. 3, No. 18, 1899, p. 191, pl. 1, figs. 7a-c; Trans. Roy. Soc. Canada, ser. 2, vol. 5, sec. 4, 1899, p. 103, pl. 5, figs. 7a-c.

Only the right valve is known; it is remarkable for its long, narrow shape and earlike anterior end. When this is concealed the shell is easily mistaken for a *Hyolithes*, the form of the posterior end and the

sculpture of the surface being like the dorsal side of a tube of that genus. The shell is about 9 mm. long and 4 mm. wide. (Matthew, 1899.)

The type specimen of this species is apparently lost for it is not present in any of the Canadian collections. As no other examples are known to us, the position of the species can not now be determined. The illustration is probably not that of a pelecypod, but possibly represents a worn *Hyolithes*.

Occurrence.—Lower Cambrian (Etcheminian): Newfoundland.

PRIMITIA SIMPLEX LLOYDIANA Jones

Primitia simplex var. *lloydiana* JONES, Ann. Mag. Nat. Hist., ser. 5, vol. 8, 1881, p. 348, pl. 20, fig. 2.

This supposed Cambrian variety of an Ordovician species can not be recognized with present information.

Occurrence.—Cambrian: St. John's, Newfoundland.

PRIMITIA SIMPLEX MILNEANA Jones

Primitia simplex var. *milneana* JONES, Ann. Mag. Nat. Hist., ser. 5, vol. 8, 1881, p. 348, pl. 20, fig. 3.

Not recognizable without further study of the types or topotypes.

Occurrence.—Cambrian: St. John's, Newfoundland.

PRIMITIA SIMPLEX SANCTOJOHANNESIANA Jones

Primitia simplex var. *sanctojohannesiana* JONES, Ann. Mag. Nat. Hist., ser. 5, vol. 8, 1881, p. 348, pl. 20, fig. 1.

Like the above, not recognizable.

Occurrence.—Cambrian: St. John's, Newfoundland.

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1865. Siluria, App., p. 519. (*Leperditia punctatissima*, new species.)

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1925. Paleozoic Crustacea, pt. 1, a bibliography of Paleozoic Crustacea. Trans. San Diego Society of Nat. Hist., vol. 4, 1925, pp. 1–88.

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WALCOTT, C. D.—Continued.

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1913. The Cambrian Faunas of China. Carnegie Institution, vol. 3, 375 pp., 29 pl. (Six species of *Aluta* described previously under *Bradoria*.)

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ZITTEL, KARL A. VON.

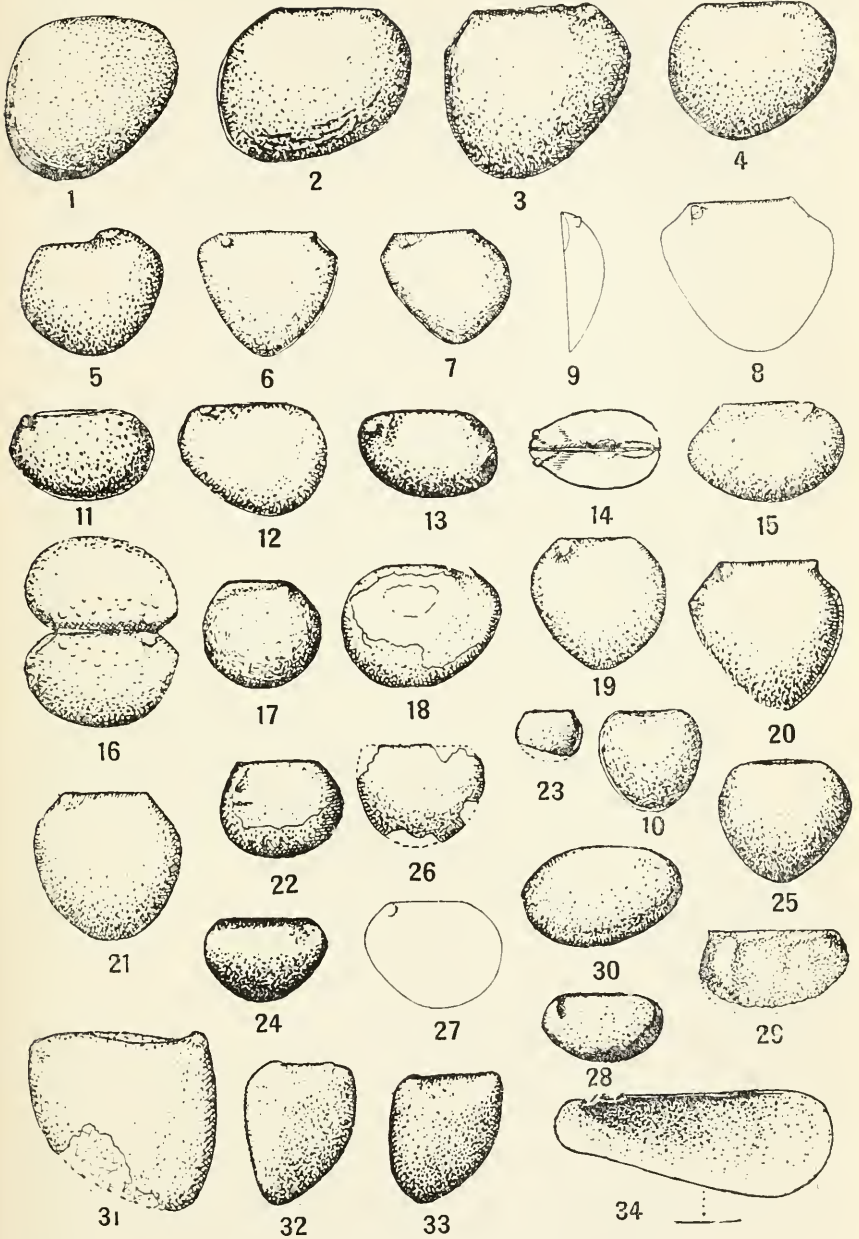
- Grundzüge der Palaeontologie (Palaeozoologie). Revised by F. Broili, Part Invertebrata, ed. 5. (Refers *Beyrichona*, *Hipponicharion*, *Bradoria*, *Aluta*, and *Polyphyma* to family Estheriidae under order Phyllopora.)
1913. Textbook of Paleontology, vol. 1, ed. 2, English edition, Translated by Charles R. Eastman with section on Ostracoda and Phyllopora, revised by R. S. Bassler. (Refers *Bradoria* and related genera to *Bradoriidae* under the Order Conchostraca.)

EXPLANATION OF PLATES

PLATE 1

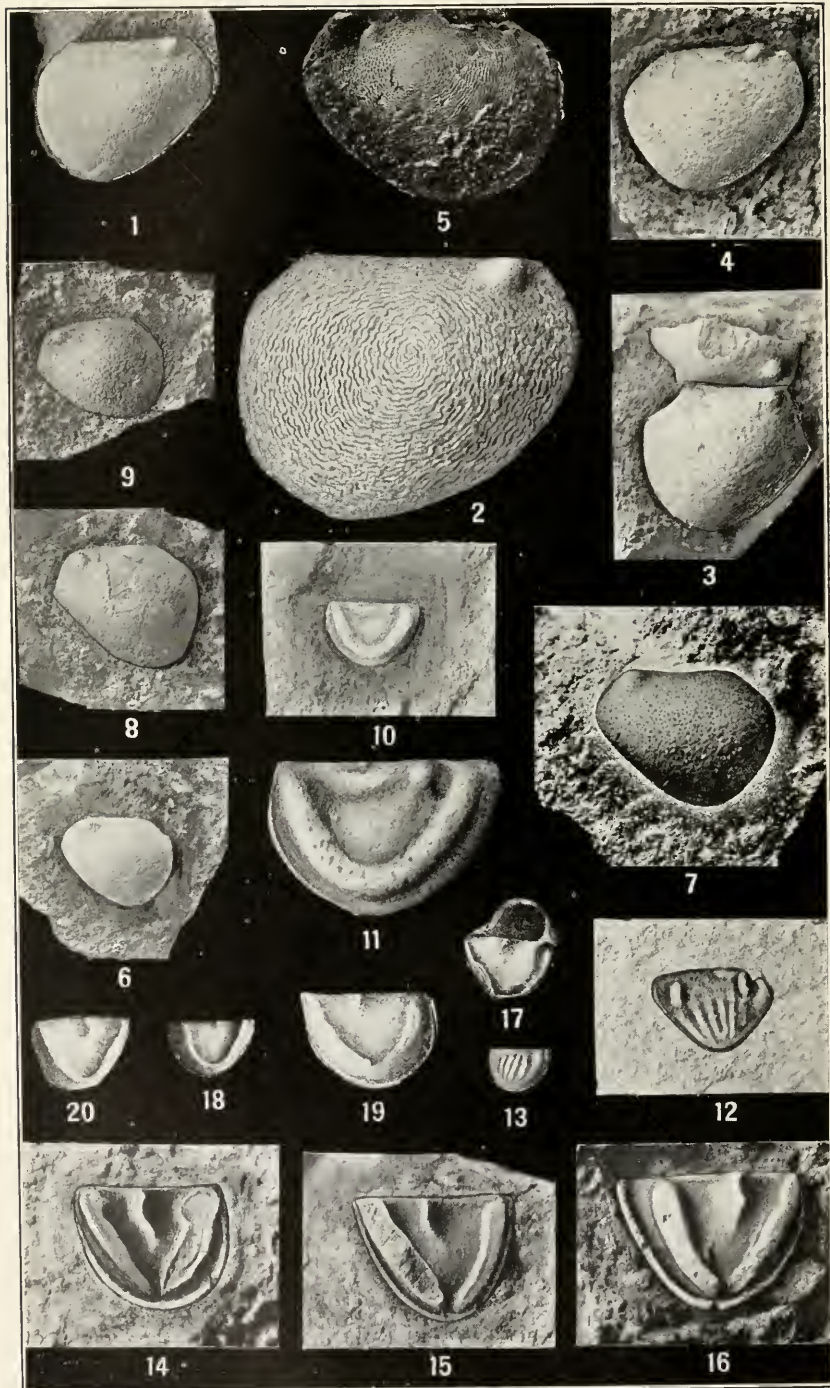
Unless otherwise stated, all the figures on this plate are copied from Matthew's work and represent his figured types, to which, in almost all cases, we have had to restrict his species.

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4. <i>Bradorona perspicator major</i> Matthew, × 4 (E3f).	
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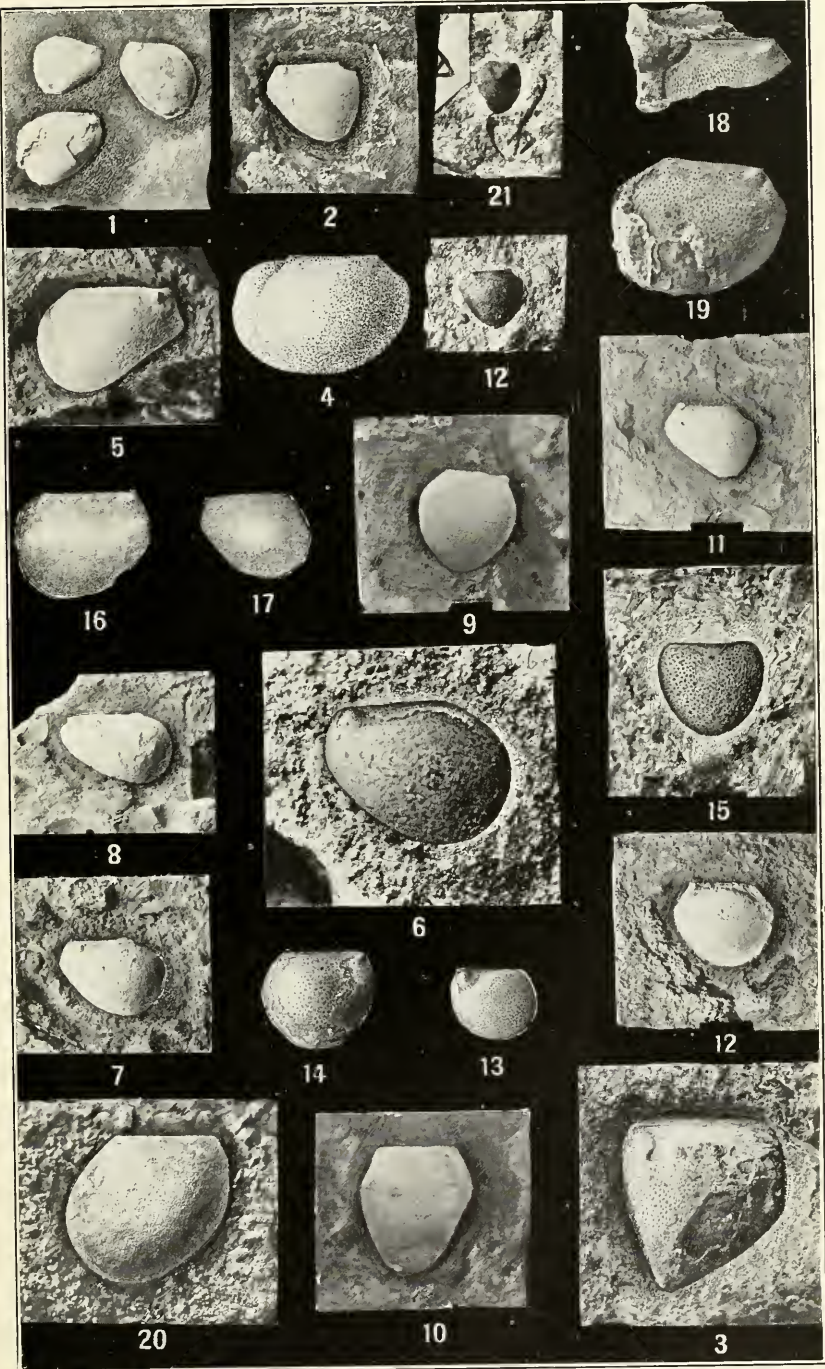
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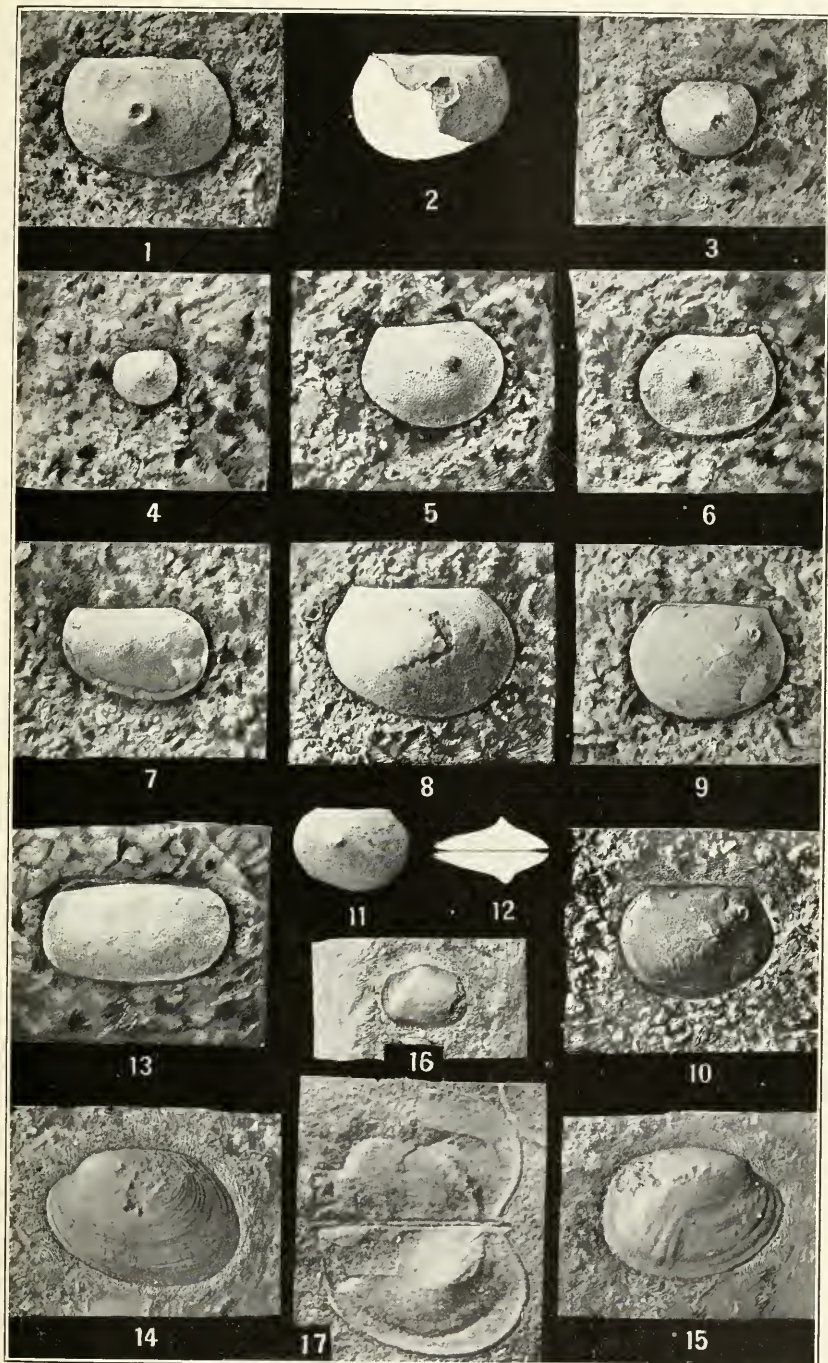
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PLATE 4

All illustrations, $\times 4$, and the specimens from the Bright Angel shale, Middle Cambrian, Grand Canyon, Ariz., except Figures 14-16.

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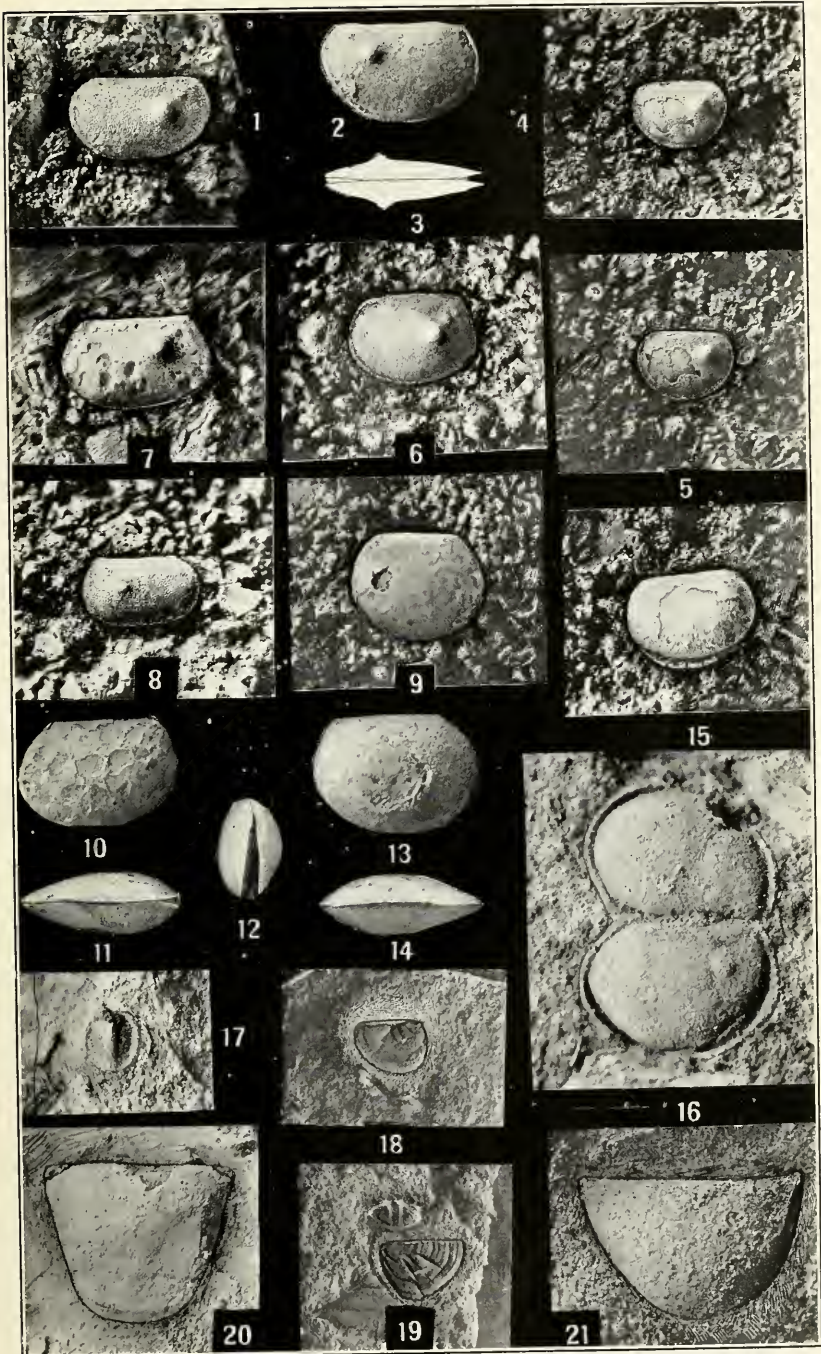
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PLATE 5

Unless otherwise stated all figures $\times 4$, and specimens from the Middle Cambrian, Bright Angel shale of the Grand Canyon, Ariz.

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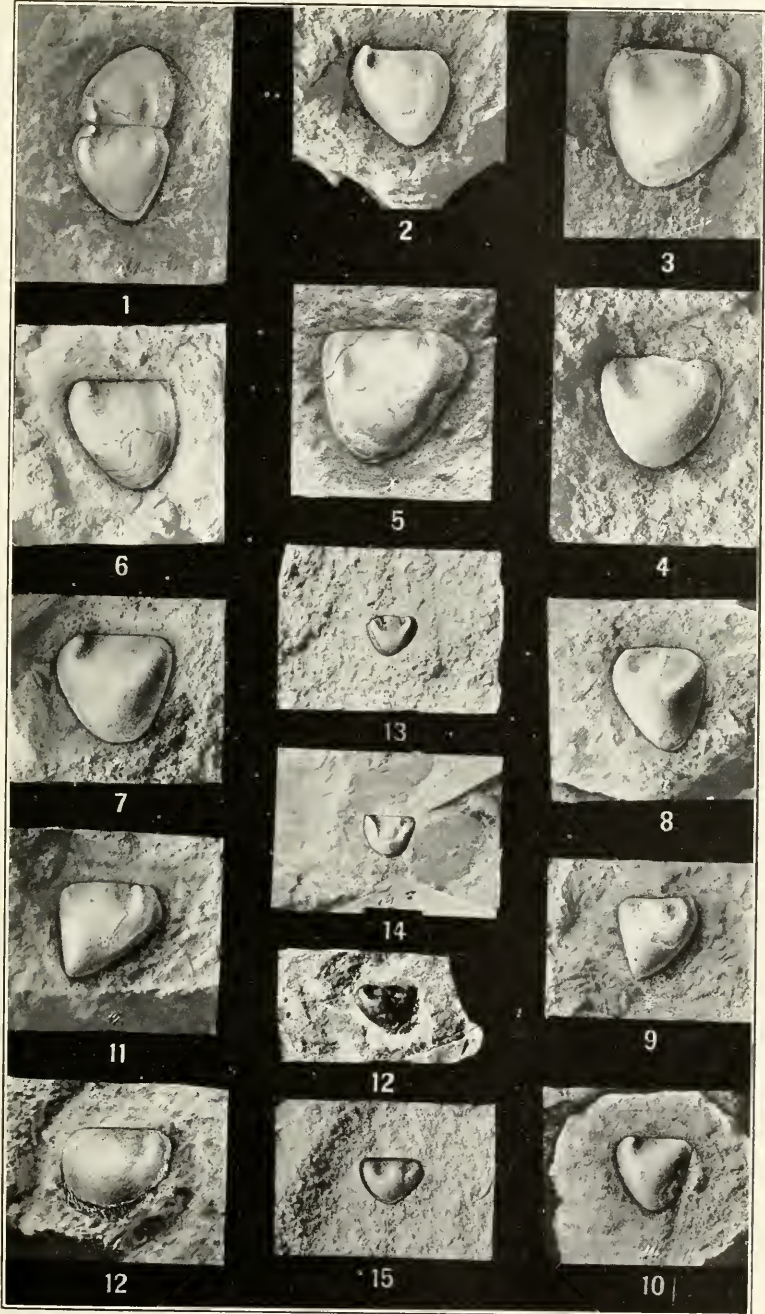
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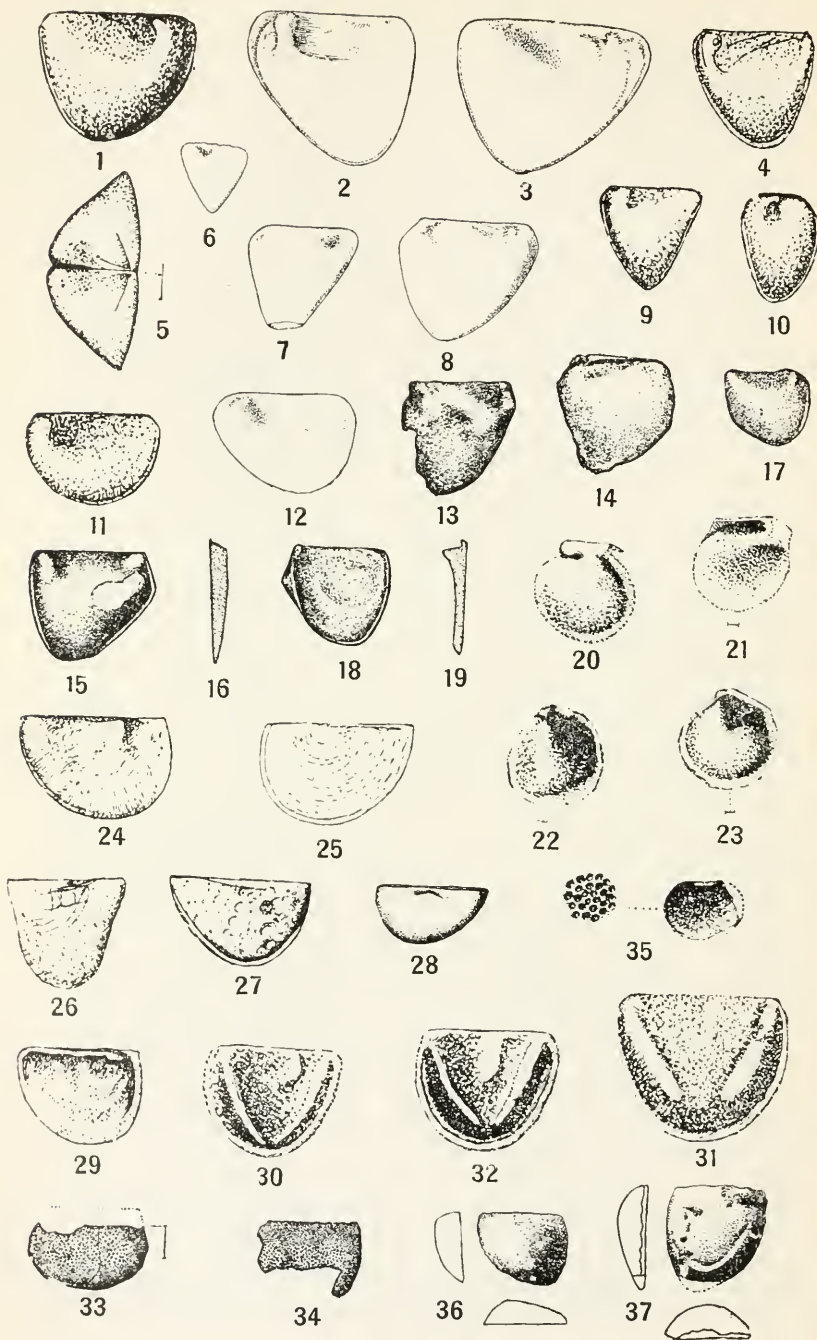
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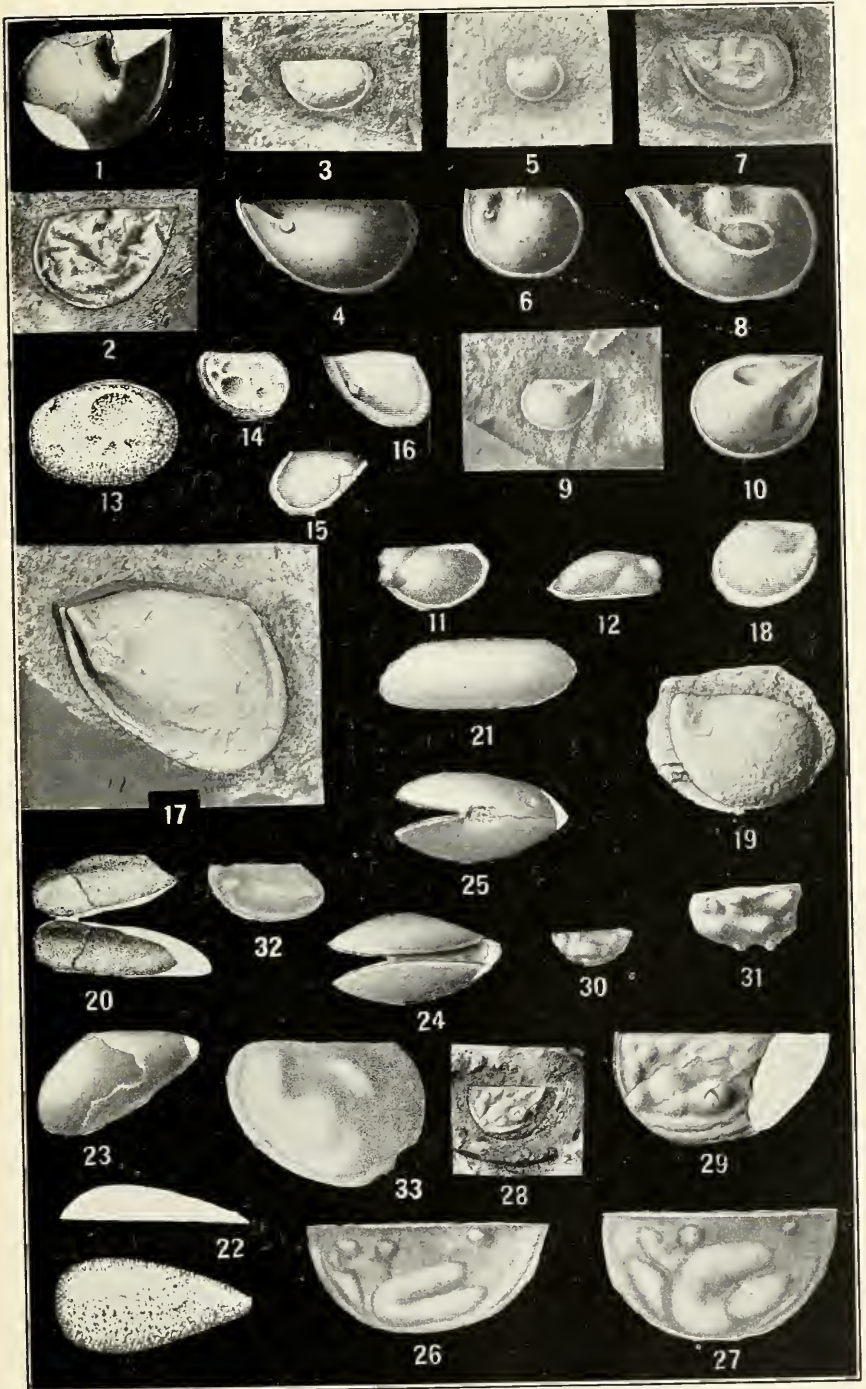
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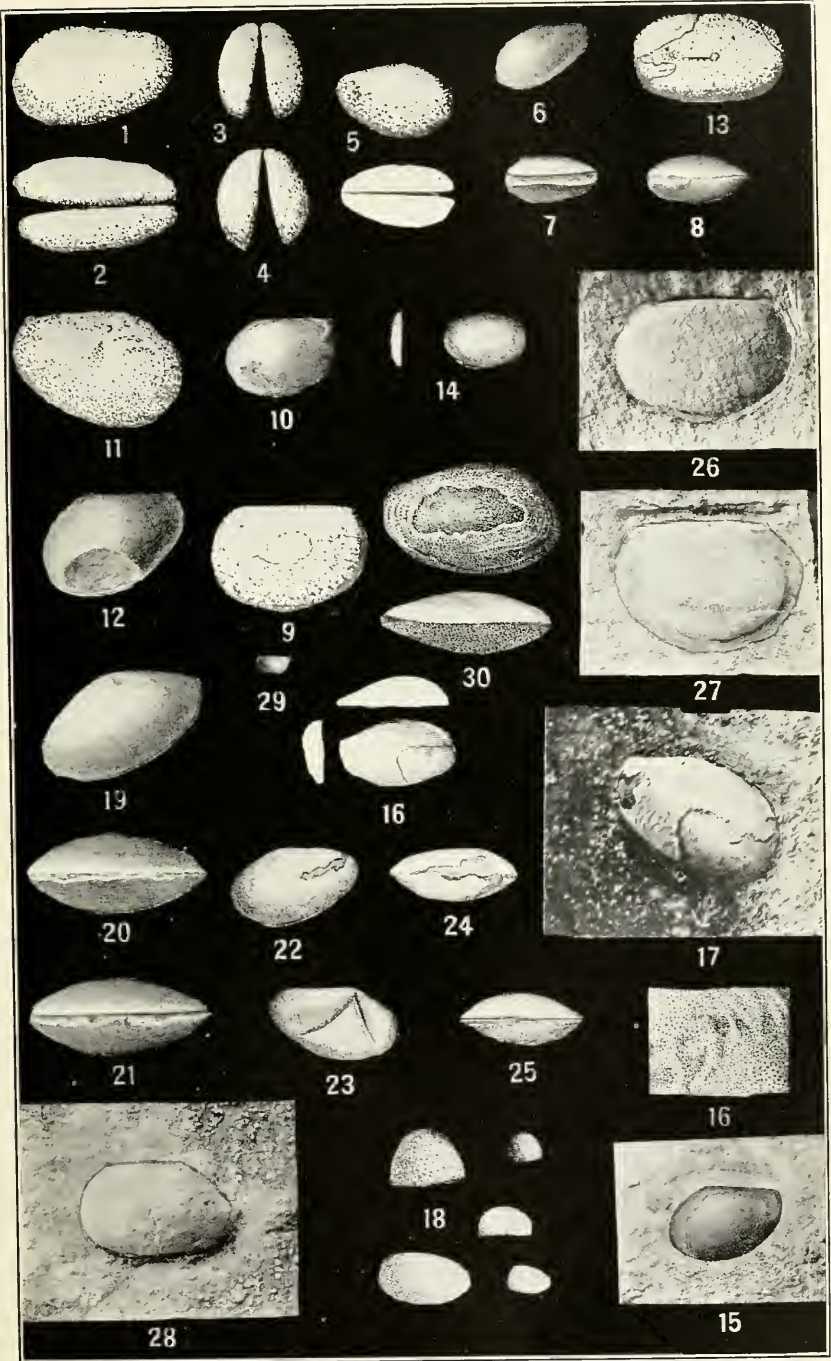
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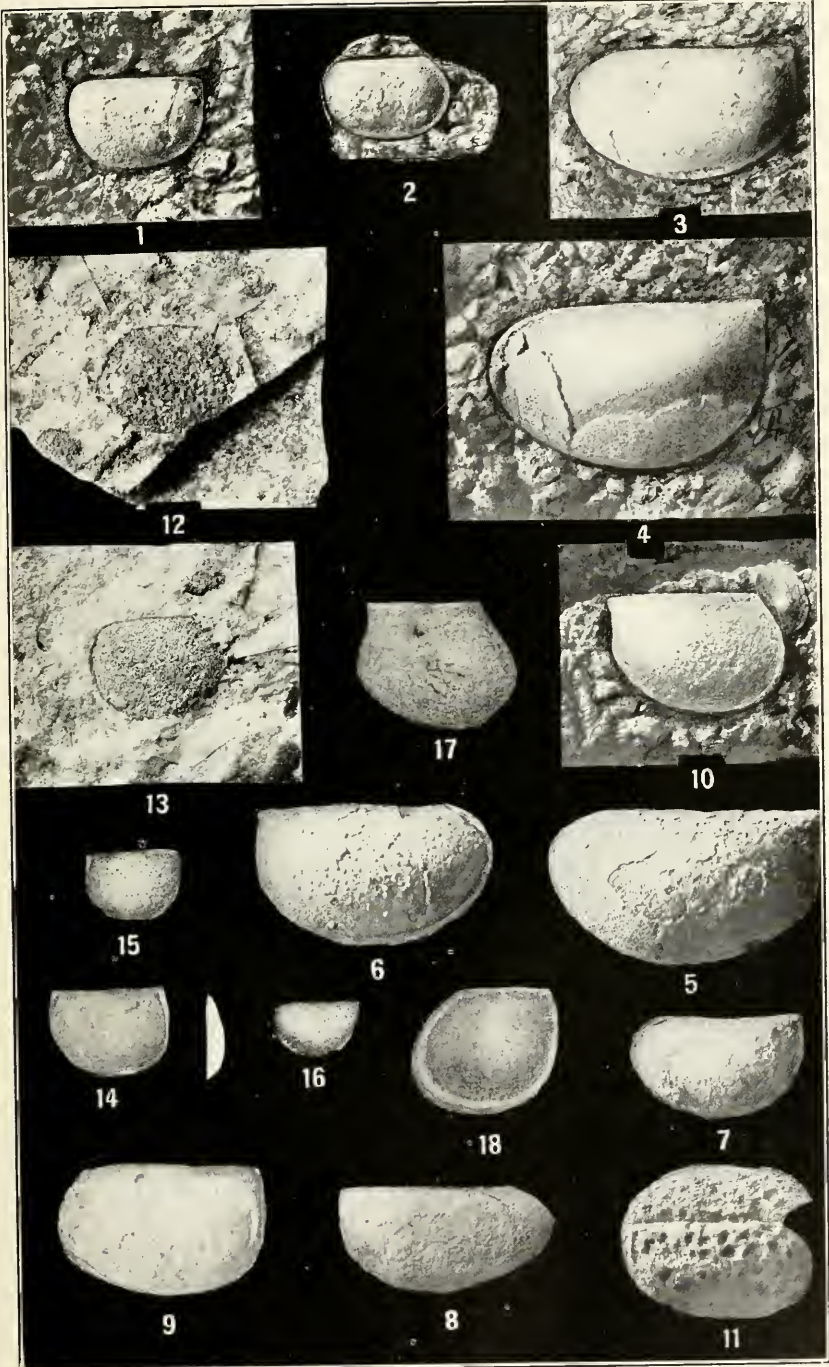
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