

DEPARTMENT OF THE INTERIOR

BULLETIN

OF THE

UNITED STATES

GEOLOGICAL SURVEY

No. 10

ON THE CAMBRIAN FAUNAS OF NORTH AMERICA

WASHINGTON
GOVERNMENT PRINTING OFFICE
1884

ADVERTISEMENT.

(Bulletin No. 10.)

The publications of the United States Geological Survey are issued in accordance with the statute, approved March 3, 1879, which declares that—

“The publications of the Geological Survey shall consist of the annual report of operations, geological and economic maps illustrating the resources and classifications of the lands and reports upon general and economic geology and paleontology. The annual report of operations of the Geological Survey shall accompany the annual report of the Secretary of the Interior. All special memoirs and reports of said Survey shall be issued in uniform quarto series if deemed necessary by the director, but otherwise in ordinary octavos. Three thousand copies of each shall be published for scientific exchanges and for sale at the price of publication; and all literary and cartographic materials received in exchange shall be the property of the United States and form a part of the library of the organization: And the money resulting from the sale of such publications shall be covered into the Treasury of the United States.”

On July 7, 1882, the following joint resolution, referring to all Government publications, was passed by Congress:

That whenever any document or report shall be ordered printed by Congress, there shall be printed in addition to the number in each case stated, the “usual number” [1,900] of copies for binding and distribution among those entitled to receive them.

Under these general laws it will be seen that none of the survey publications are furnished to it for gratuitous distribution. The 3,000 copies of the annual report are distributed through the document rooms of Congress. The 1,900 copies of each of the publications are distributed to the officers of the legislative and executive departments and to stated depositories throughout the United States.

Except, therefore, in those cases where an extra number of any publication is supplied to this office by special resolution of Congress, as has been done in the case of the second, third, fourth, and fifth annual reports, or where a number has been ordered for its use by the Secretary of the Interior, as in the case of Williams's Mineral Resources, the survey has no copies of any of its publications for gratuitous distribution.

ANNUAL REPORTS.

Of the Annual Reports there have been already published:

I. First Annual Report to the Hon. Carl Schurz, by Clarence King. 1880. 8°. 79 pp. 1 map.—A. preliminary report describing plan of organization and publications.

II. Report of the Director of the United States Geological Survey for 1880-'81, by J. W. Powell. 1882. 8°. lv, 588 pp. 61 pl. 1 map.

III. Third Annual Report of the United States Geological Survey, 1881-'82, by J. W. Powell. 1883. 8°. xviii, 564 pp. 67 pl. and maps.

IV. Fourth Annual Report of the United States Geological Survey, 1882-'83, by J. W. Powell. 1884. 8°. xii, 473 pp. 85 pl. and maps.

The Fifth Annual Report is in press.

MONOGRAPHS.

So far as already determined upon, the list of the Monographs is as follows:

I. The Precious Metals, by Clarence King. In preparation.

II. Tertiary History of the Grand Cañon District, with atlas, by Capt. C. E. Dutton. Published.

III. Geology of the Comstock Lode and Washoe District, with atlas, by George F. Becker. Published.

IV. Comstock Mining and Miners, by Eliot Lord. Published.

V. Copper-bearing Rocks of Lake Superior, by Prof. R. D. Irving. Published.

VI. Older Mesozoic Flora of Virginia, by Prof. Wm. M. Fontaine. Published.

VII. Silver-lead Deposits of Eureka, Nevada, by Joseph S. Curtis. Published.

VIII. Paleontology of the Eureka District, Nevada, by Charles D. Walcott. In press.

IX. Brachiopoda and Lamellibranchiata of the Green Marls and Clays of New Jersey, by R. P. Whitfield.

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- Geology and Mining Industry of Leadville, with atlas, by S. F. Emmons. In preparation.
 Geology of the Eureka Mining District, Nevada, with atlas, by Arnold Hague. In preparation.
 Lake Bonneville, by G. K. Gilbert. In preparation.
 Dinosauria. A Monograph on an extinct order of Ungulates, by Prof. O. C. Marsh. In preparation.
 Sauroptoda, by Prof. O. C. Marsh. In preparation.
 Stegosauria, by Prof. O. C. Marsh. In preparation.
 Of these Monographs, Nos. II, III, IV, V, VI, and VII are now published, viz:
 II. Tertiary History of the Grand Cañon District, with atlas, by C. E. Dutton, Capt. U. S. A. 1882. 4°. 264 pp. 42 pl. and atlas of 26 double sheets folio. Price \$10.12.
 III. Geology of the Comstock Lode and Washoe District, with atlas, by G. F. Becker. 1882. 4°. xv, 422 pp. 7 pl. and atlas of 21 sheets folio. Price \$11.
 IV. Comstock Mining and Miners, by Eliot Lord. 1883. 4°. xiv, 451 pp. 3 pl. Price \$1.50.
 V. Copper-bearing Rocks of Lake Superior, by Prof. R. D. Irving. 1883. 4°. xvi, 464 pp. 29 pl. Price \$—.
 VI. Contributions to the Knowledge of the Older Mesozoic Flora of Virginia, by Wm. M. Fontaine. 1883. 4°. xi, 144 pp. 54 l. 54 pl. Price \$—.
 VII. Silver-lead Deposits of Eureka, Nevada, by Joseph S. Curtis. 1884. 4°. xiii, 200 pp. 15 pl. Price \$—.
 Nos. VIII and IX are in press and will soon appear. The others, to which numbers are not assigned, are in preparation.

BULLETINS.

The Bulletins of the Survey will contain such papers relating to the general purpose of its work as do not properly come under the heads of ANNUAL REPORTS or MONOGRAPHS.

Each of these Bulletins will contain but one paper, and be complete in itself. They will, however, be numbered in a continuous series, and will in time be united into volumes of convenient size. To facilitate this, each Bulletin will have two paginations, one proper to itself, and one which belongs to it as part of the volume.

Of this series of Bulletins Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 are already published:

1. On Hypersthene-Andesite and on Triclinic Pyroxene in Angitic Rocks, by Whitman Cross, with a Geological Sketch of Buffalo Peaks, Colorado, by S. F. Emmons. 1883. 8°. 42 pp. 2 pl. Price 10 cents.
2. Gold and Silver Conversion Tables, giving the coining value of Troy ounces of fine metal, &c., by Albert Williams, jr. 1883. 8°. ii, 8 pp. Price 5 cents.
3. On the Fossil Faunas of the Upper Devonian along the meridian of 76° 30', from Tompkins County, N. Y., to Bradford County, Pa., by Henry S. Williams. 1884. 8°. 36 pp. Price 5 cents.
4. On Mesozoic Fossils, by Charles A. White. 1884. 8°. 36 pp. 9 pl. Price 5 cents.
5. A Dictionary of Altitudes in the United States, compiled by Henry Gannett. 1884. 8°. 325 pp. Price 20 cents.
6. Elevations in the Dominion of Canada, by J. W. Spencer. 1884. 8°. 43 pp. Price 5 cents.
7. *Mapoteca Geologica Americana*. A catalogue of geographical maps of America (North and South), 1752-1881, by Jules Marcou and John Belknap Marcou. 1884. 8°. 184 pp. Price — cents.
8. On Secondary Enlargements of Mineral Fragments in Certain Rocks, by R. D. Irving and C. R. Vanhise. 1884. 8°. 56 pp. Price 10 cents.
9. A Report of the Work done in the Washington Laboratory during the fiscal year 1883-'84. F. W. Clarke, chief chemist; T. M. Chatard, assistant. 1884. 8°. 40 pp. Price 5 cents.
10. On the Cambrian Faunas of North America. Preliminary studies by Charles Doolittle Walcott. 1884. 8°. 74 pp. Price 5 cents.

STATISTICAL PAPERS.

A fourth series of publications having special reference to the mineral resources of the United States is contemplated. Of that series the first has been published, viz: Mineral Resources of the United States, by Albert Williams, jr. 1883. 8°. xvii, 813 pp. Price 50 cents.

Correspondence relating to the publications of the Survey, and all remittances, which must be by postal note or money order, should be addressed to the

DIRECTOR OF THE UNITED STATES GEOLOGICAL SURVEY,

Washington, D. C.

WASHINGTON, D. C., August 31, 1884.

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UNITED STATES GEOLOGICAL SURVEY

J. W. POWELL DIRECTOR

O N

THE CAMBRIAN FAUNAS

OF

NORTH AMERICA

PRELIMINARY STUDIES

BY

CHARLES DOOLITTLE WALCOTT



WASHINGTON
GOVERNMENT PRINTING OFFICE
1884

DEPARTMENT OF THE INTERIOR,
UNITED STATES GEOLOGICAL SURVEY,
Washington D. C., July 1, 1884.

SIR: Herewith I have the honor to transmit the first of my preliminary studies on the Cambrian Faunas of North America.

The faunas studied are under discussion at the present time, and an early publication is desirable.

Very respectfully,

CHARLES D. WALCOTT.

Hon. J. W. POWELL,
Director U. S. Geological Survey.

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ON THE CAMBRIAN FAUNAS OF NORTH AMERICA.

PRELIMINARY STUDIES.

By CHARLES D. WALCOTT.

REVIEW OF THE FAUNA OF THE SAINT JOHN FORMATION CONTAINED IN THE HARTT COLLECTION AT CORNELL UNIVERSITY.¹

During the summer of 1877 the writer visited Saint John, N. B., and taking advantage of information kindly given by Mr. G. F. Mat-

¹The term "Saint John Group" was first proposed in 1865 (Observations on the Geology of Southern New Brunswick, Fredericton, N. B., pp. 26-32) by Messrs. L. W. Bailey, G. F. Matthew, and C. F. Hartt. Subsequently, Mr. J. W. Dawson (Acad. Geol., 2nd ed., p. 638, 1868) proposed to substitute the name Acadian for the same formation. He says: "This formation has as yet been known as the Saint John Group; but I think this name unsuitable, both on account of the number of places known as Saint John, and on account of the variety of formations occurring near Saint John, in New Brunswick, and would therefore propose for the group now under consideration, characterized by Paradoxides, Conocephalites, &c., and the oldest known member of the Palæozoic of America, the name Acadian Group, by which I hope it will be known to geologists in whatever part of America it may be recognized."

The geographic area bearing the name of Acadia is defined by Mr. Dawson (*Ibid.*, p. 5) as "distinguished from all the neighboring parts of America by the enormous and remarkable development within it of rocks of the Carboniferous and Triassic systems." This certainly renders the name inapplicable as a substitute for a well-defined local name previously given to the formation under consideration.

Saint John, N. B., is quite as well known as Trenton, New York, from which the well-known Trenton limestone is named. We would not give as a reason for changing that name that other towns in the United States bear the name of Trenton.

Mr. Matthew, in speaking of the Saint John formation, says (Trans. Roy. Soc. Canada, vol. i, p. 87, 1882): "From these reports and from the map it will be seen that the strata of the Saint John Group fill a number of narrow, trough-like basins lying between the Bay of Fundy and the central Carboniferous area of New Brunswick. Of these basins, that on which the city of Saint John is situated is the most important, and it is here, also that the life of the period can be studied to the best advantage. The Saint John basin lies diagonally across the ridges of Huronian rock that are found in the eastern part of Saint John County; and touches the ridge of Laurentian rocks that divides this county from Kings."

I cannot but think that if we pay attention to the law of priority, justice to the original discoverers of this group requires that the name of Saint John formation should be used as expressing the division of the Lower Cambrian, so well developed at Saint John.

The name Saint John or Acadian cannot well be applied to the Newfoundland or Braintree Paradoxides beds. The three localities present local differences and characters which, while permitting their being united under the general term Lower Cambrian, render it necessary to use a local name for the formation in each of the widely-separated localities.

thew, obtained a large collection of fossils from the typical localities at Saint John, Ratcliff's Millstream, and Portland, from which Mr. C. F. Hartt procured the collection described by him in the second edition of Dawson's Acadian Geology. Subsequently when working over the material, it was with great difficulty that more than the common species could be identified from the descriptions, and few figures given in the Acadian Geology. The writer at that time formed the plan of illustrating the original typical Hartt collection and also the entire fauna, as far as possible. His own collection afterward went to the Museum of Comparative Zoölogy at Cambridge, Mass., and it was not until the latter part of 1883 that the trustees of Cornell University came in possession of the Hartt collection. Through the co-operation of Mr. H. S. Williams, paleontologist of the university, the loan of the collection was obtained for the purpose of illustrating the type specimens and such other material as would add to our knowledge of the fauna. In writing to Mr. L. W. Bailey, of Fredericton, N. B., and Mr. G. F. Matthew, to secure their co-operation, the writer learned for the first time that Mr. Matthew was engaged on a monograph of the fauna of the Saint John formation. The plan of illustrating the entire fauna was at once changed so as to include only the Hartt collection, and Mr. Matthew was requested to propose specific names for the new species with the exception of one form with which the writer wished to connect the names of Mr. Hartt and Mr. Matthew, the two gentlemen who first gave to the scientific world a definite knowledge of this early Cambrian group. Mr. Matthew kindly accepted this proposal, and the writer proceeded with the work, using only the material contained in the Hartt collection.

Mr. Matthew's valuable paper on the genus *Paradoxides* of the Saint John Group, has already appeared (Trans. Roy. Soc. Canada, vol. i, 1882), and from it we learn that he recognizes three well-defined species and six varieties: *Paradoxides lamellatus*, Hartt; *P. lamellatus*, var. *Loricatus*, Matthew; *P. Acadicus*, Matthew; *P. Eteminicus*, Matthew; *P. Eteminicus*, vars. *suricoides*, *breviatus*, *Quacoensis*, *Malicitus* and *pontificalis*.

In the Hartt collection we find as the types of *P. lamellatus* a portion of the head of two specimens. The species appears to be of rare occurrence. Mr. Matthew illustrates but a fragment of the head of a specimen which he considers as indicating a variety of *P. lamellatus*.

Two other species occur in the collection that were not named by Mr. Hartt. *P. Acadicus*, Matt., is represented by the larger portion of an entire individual, and *P. Eteminicus*, Matt., by numerous fragments of the head. The *P. Micmac*, figured by Mr. Dawson (Acad. Geol. 2d ed., p. 657), is not represented in the collection, and Mr. Matthew writes me that the original specimens were destroyed in the great Saint John fire of 1877, and that he is unable to identify the species. The figure is a restoration, and no description accompanies it; on this account it ap-

pears best to drop the name from the list of species composing the Saint John fauna, as an undefined and undetermined species.

In reviewing the fauna as shown in the Hartt collection, we find the Echinodermata represented by single detached plates of one species, *Eocystites primævus*, Bill. A somewhat similar form occurs in the Menavian group of Wales, under the name of *Protocystites Menevensis*, Hicks.

Among the Brachiopods, *Lingula? Dawsoni*, Matt., *Acrothele Matthewi*, Hartt, *Obolella transversa*, Hartt., *Obolella*, sp., *Orthis Billingsi*, Hartt, and *Orthis*, sp.?, show how rich and varied this class must have been at the time of the deposition of the Saint John formation.

The new type representing the Gasteropoda, *Harttia Matthewi*, is of special interest owing to its being the oldest representative of the class known on the North American continent, and the section of the family which it approaches most nearly is doubtfully known, if at all, below the Tertiary system. The species *Palæacmea? Acadica*, is as yet doubtfully referred to the gasteropoda.

Of the Pteropoda there are three species, *Hyolithes Acadica*, Hartt, *H. Danianus*, Matt., and *H. Micmac*, Matt. The former is not unlike *H. primordialis*, Hall (Sixteenth Ann. Rep. N. Y. State Cab. Nat. Hist., p. 135*), of the Potsdam sandstone of Wisconsin, and the second approaches *H. cinctus*, Barr. (Syst. Sil. Bohême, vol. iii, p. 78), of the Cambrian² of Bohemia.

The class Pœcilopoda, order Trilobita, is the dominant type in the Saint John fauna, as it is in all the known Cambrian faunas, and is represented by *Agnostus Acadicus*, Hartt; *Microdiscus Dawsoni*, Hartt, *M. punctatus*, Hartt; *Paradoxides lamellatus*, Hartt, *P. Acadicus*, Matt., *P. Eteminicus*, Matt.; and varieties *suricoides*, *breviatus*, *Malicitus*, *pontificalis* and *Quacoensis*; *Conocoryphe Matthewi*, Hartt, *C. elegans*, Hartt, *C. Walcotti*, Matt., *C. (Salteria) Baileyi*, Hartt; *Ptychoparia Robbi*, Hartt, *P. Ouangondiana*, Hartt, and variety *Aurora*; *P. quadrata*, Hartt, *P. Orestes*, Hartt, and variety *Thersites*, and *P. tener*, Hartt.

Mr. Hartt, described, in addition to these, *Conocephalites gemini-spinosus* = *Conocoryphe Matthewi*; *Conocephalites formosus* = *Ptychoparia Robbi*; *Conocephalites Aurora* = *Ptychoparia Ouangondiana*, variety *Aurora*; *Conocephalites Halli* = *Ptychoparia Orestes*; *Conocephalites Thersites* = *Ptychoparia Orestes*, variety *Thersites*; *Conocephalites neglectus* = *Ptychoparia tener*. It is with great reluctance that I reduce the above-named species to varieties and synonyms of other species, and it was not until after many comparisons and a study of all the material in the collection that it was done. Good figures are given of the types of each of Mr. Hartt's species, and the student has before him the original descriptions, so that he can judge for himself and not entirely rely upon the writer to form his opinion of the value of the species.

² The Cambrian system, as referred to in this paper, is that series of strata characterized by the first fauna of Barrande.

In review we find 14 genera, 26 species, and 6 varieties, distributed as follows: Echinodermata, 1 genus, 1 species; Brachiopoda, 5 genera, 7 species; Gasteropoda, 1 genus, 1 species; Pteropoda, 1 genus, 3 species; Trilobita, 6 genera, 14 species, 6 varieties.

That Mr. Matthew's researches will increase this number of species there is little doubt, and it is not improbable that some of the species of Mr. Hartt which are placed in this paper as synonyms of some others may yet prove to be distinct.

Mr. Matthew states (Trans. Roy. Soc. Canada, vol. i, p. 89) that among the collections made by the Canadian Geological Survey in New Brunswick, Mr. Billings recognized fragments of the genera *Elliptocephalus* and *Salterella*, and the remains of two species of *Hyalolithes*. "Besides these, there are the supposed plant remains, *Palæophycus*, *Eophyton*, etc., of the higher divisions of the Saint John Group."

While studying the species, the question of their correct generic reference came up, and a number of species of three different genera were found to be arranged under the genus *Conocephalites*, a genus that, with the greatest respect for the opinion of its author and his work, I cannot see the way clear to accept. The reasons for this will be found under remarks on the genus *Ptychoparia*. The new subgenus *Salteria* may be of doubtful subgeneric value, but with the characters of *C. (Salteria) venulosa*, Salter, before us, a subgeneric group, appears to be indicated.

The fauna of the Saint John Group has been most happily compared by authors with that of the Paradoxides fauna of Bohemia, Wales, and Sweden. The resemblance to that of the Menevian of Wales is very striking, and the relationship so close that we are in doubt if there are not more identical species than *Microdiscus punctatus* in the two faunas.

The more closely related species are:

SAINT JOHN.	MENEVIAN.
<i>Obolella transversa</i>	<i>Obolella sagittalis</i> .
<i>Agnostus Acadicus</i>	<i>Agnostus Cambrensis</i> .
<i>Microdiscus punctatus</i>	<i>Microdiscus punctatus</i> .
<i>Conocoryphe Matthewi</i>	<i>Conocoryphe Solvensis</i> .
<i>Conocoryphe elegans</i>	<i>Conocoryphe bufo</i> .
<i>C. (Salteria) Baileyi</i>	<i>C. (Salteria) venulosa</i> .
<i>Ptychoparia Robbi</i> ..	<i>Ptychoparia applanata</i> .

A comparison with the Swedish Paradoxides fauna gives:

SAINT JOHN.	SWEDISH.
<i>Obolella transversa</i>	<i>Obolella sagittalis</i> .
<i>Agnostus Acadicus</i> ..	<i>Agnostus brevifrons</i> .
<i>Conocoryphe Matthewi</i>	<i>Conocoryphe exsulans</i> .
<i>Conocoryphe elegans</i>	<i>Conocoryphe Dalmani</i> .
<i>Ptychoparia Robbi</i>	<i>Ptychoparia cristata</i> .

With the Bohemian Paradoxides fauna :

SAINT JOHN.	BOHEMIAN.
<i>Agnostus Acadicus</i>	<i>Agnostus integer</i> .
<i>Hyolithes Danianus</i>	<i>Hyolithes cinctus</i> .
<i>Conocoryphe Matthewi</i>	<i>Conocoryphe coronatus</i> .
<i>Conocoryphe elegans</i>	<i>Conocoryphe Sulzeri</i> .
<i>Ptychoparia Robbi</i>	<i>Ptychoparia Emmrichi</i> .

Mr. Matthew calls attention to the close interrelationship of the species of the Saint John Paradoxides and to the fact that they belong to a group characterized by a continuous eye-lobe, a feature developed in *Paradoxides rugulosus*, Corda (Syst. Sil. Bohême., vol. i, p. 374), of Bohemia. In the genus *Anopolenus* (Quar. Jour. Geol. Soc., vol. xxi, p. 177) the eye-lobes are continuous, but of a different character from the Saint John Paradoxides. *Olenellus asaphoides* (Amer. Jour. Sci., vol. xiii, p. 265) shows a continuous eye-lobe in some of the younger stages of development, a character not retained in the adult individual.

In comparing the Saint John fauna of Saint John with that of other localities of the Saint John fauna in North America, the first to be noted is that of Manuel's Brock, near Conception Bay, Newfoundland, as described by Mr. J. F. Whiteaves (Amer. Jour. Sci., 3d ser., vol. xvi, p. 224, 1878).

Mr. Whiteaves identifies of the Saint John fauna : *Agnostus Acadicus*, *Microdiscus Dawsoni*, *Microdiscus punctatus*, *Paradoxides*, sp.?, *C. (Salteria) Baileyi*, *Ptychoparia tener*, *Ptychoparia Orestes*?

On the authority of Mr. Alex. Murray, the shales containing this fauna are considered by Mr. Whiteaves as lower than the strata from which Mr. Billings obtained a strongly-marked Cambrian fauna that he refers to the Menevian Group (Can. Nat., 2d ser., vol. vi, p. 470, 1872).

From this horizon Mr. Billings described *Obolella? miser*, *Straparollina remota*, *Hyolithes excellens*, *Paradoxides tenellus*, *Paradoxides decorus*, *P. (Anopolenus) venustus*, *Agraulos affinis*, *A. socialis*, *A. strenuus*, *Ptychoparia (Solenopleura) communis*.

Mr. Billings also describes *Stenothecca pauper* and *Scenella reticulata*, from Conception Bay, the stratigraphic horizon being a little above the Manuel's Brook shales containing the Saint John fauna. To these we have to add the large *Paradoxides Bennetti*, Salter (Quart. Journ. Geol. Soc., vol. xv, p. 552, 1859), and *Bathyrurus = Solenopleura gregaria*, Billings (Pal. Foss., vol. i, p. 363, 1865), from the Paradoxides slates of Saint Mary's Bay, Newfoundland, which gives a total of fourteen described species from Paradoxides beds above the Saint John fauna.

From the sections given by Mr. Murray (Geol. Surv. Newfoundland, p. 157, 1881), we learn that the shales carrying the Saint John fauna are the lowest fossiliferous strata in Newfoundland, and that the Paradoxides beds above carry a fauna unlike the Saint John fauna. This proves the latter fauna to be the oldest known on the American continent, and when compared to the older Cambrian faunas of Wales, to

be low down in the Menevian if not representative of that of portions of the Harlech and Longmynd groups.

Near Saint John, N. B., there is a commingling of representative species that are distributed in the St. David's section of Wales, from the Harlech to the Upper Menevian, a fact that tells us plainly that we need not look for a close similarity in the succession of individual species in sections of the same relative geologic position when widely separated. The physical conditions of environment and the geographic distribution of species tend to variation in the assemblage of forms at localities but slightly separated, and still more when widely distant from each other.

In the Braintree argillites there are four species, *Hyolithes Shaleri*, Walcott (this bulletin), *Paradoxides Harlani*, Green (Amer. Journ. Sci., vol. xxv, p. 336, 1834), *Ptychoparia Rogersi*, Walcott (this bulletin), and *Agraulos quadrangularis*, Whitfield (Bull. Amer. Mus. Nat. Hist., vol. i, p. 147, 1884).

Hyolithes Shaleri is closely allied to *Hyolithes excellens*, Billings (Pal. Foss., vol. ii, pt. 1, p. 70, 1874).

The *Paradoxides Harlani* is of the type of *Paradoxides Bennetti*, of Newfoundland, as found above the Saint John fauna, and corresponds to the Bohemian group of the genus typified by *P. spinosus*, Boeck, and the Menevian *P. Hicksii*, Salter. *Agraulos quadrangularis*, Whitfield, is a type present in the *Paradoxides* horizon in Newfoundland, as *A. socialis*, *A. strenuus*, and *A. affinis*, Billings (Pal. Foss., vol. ii, pt. 1, p. 71), in the Menevian of Wales, as *A. longicephalus*, Hicks (Quar. Jour. Geol. Soc., vol. xxviii, p. 176), in Bohemia, as *A. ceticephalus*, Barrande (Syst. Sil. Bohême., vol. i, p. 405). *Ptychoparia Rogersi* is more of the type of *Ptychoparia Emmrichi*, Barrande, of Bohemia.

Up to the present time no other localities of the *Paradoxides* fauna have been discovered in North America.

The relations of the Saint John fauna to the remaining portion of the *Paradoxides* fauna in Newfoundland we have mentioned, but as yet no section has shown the connection of the *Paradoxides* fauna with that of the next superior or Georgian fauna. As I am engaged on a review of the latter fauna, the discussion will be omitted here to appear in a paper on that portion of the Cambrian fauna.

Genus EOCYSTITES, Billings.

EOCYSTITES PRIMÆVUS, Billings.

Plate i, fig. 2.

Eocystites primævus, Billings, 1868, Acadian Geology, Dawson, 2d ed., p. 643.

No description accompanies the illustration of the single plate of this form, and, in fact, little can be said of it from the material in the collection.

The plates are polygonal in outline, variable in size and form, elevated at the center, and ornamented by 9, 10, or 11 principal ridges radiating from the center with smaller ridges coming in between the larger ones, usually showing a pentagonal arrangement. The plates vary from 3 to 5 millimeters in diameter. It is quite probable that a new generic form is indicated, but in its relations to other genera nothing can be determined. *Protocystites Menevensis*, Hicks, evidently belongs to a similar type, if not to the same genus.

Formation and locality.—Cambrian. Saint John formation, Ratcliff's Millstream, N. B.

Genus LINGULA, Bruguière.

LINGULA ? DAWSONI, Matthew.

Plate v, fig. 8.

Lingula ? Dawsoni, Matthew, 1884. MSS.

Shell small, broadly subelliptical, subattenuate towards the beak; margins gradually expanding and curving from the beak to the center, where the shell has its greatest width, and thence narrowing towards the front, which is broadly rounded. General surface depressed convex, becoming more convex towards the beak.

Surface marked by fine undulating concentric lines crossed by radiating lines that are seen only by the aid of a strong magnifying glass.

In form this species approaches *Lingulella ferruginea*, Salter (See Man. Brit. Foss. Brach., Davidson, vol. iii, p. 336), of the Menevian formation of Wales quite closely, but with only a specimen of the ventral (?) valve to compare with it, it is difficult to satisfactorily determine its specific relations.

Formation and locality.—Cambrian. Saint John formation, Saint John, N. B.

The following notice of a larger shell than *Acrothele Matthewi* appears on page 644 of the Acadian Geology as a new species of *Lingula*:

"*Lingula*, n. sp., Hartt, differs from the above (*A. Matthewi*) in being almost straight in front, broadly rounded at the sides, and narrowed towards and pointed at the umbo. It was also larger, thicker, and more convex."

The original specimen I have failed to find in the collections, and no form corresponding to it has been observed.

Genus ACROTHELE, Linnarsson.

ACROTHELE MATTHEWI, Hartt, sp.

Plate i, figs. 4, 4a.

Lingula Matthewi, Hartt, 1868, Acadian Geology, Dawson, 2d ed., p. 644, fig. 221.

Description.—"Dorsal valve, circular in outline or very slightly wider than long, extremely flat, the convexity being scarcely noticeable; shell

very thin; on each side a segment, such as would be cut off by a chord running from the umbo to the extremity of the transverse diameter, is slightly turned up on the margin.

"Inside, a strong mesial ridge, rounded and of moderate width, runs from the umbo to a point a little beyond the middle of the shell; at the umbo this ridge bears a small nailhead-like process or swelling, and there are two minute and extremely short secondary ridges, originating from the head of the primary, and extending obliquely backwards. Inner surface marked with numerous indistinct and irregular concentric striae; outer surface not visible."

A study of the type specimen of this species, which is a cast of the interior of the dorsal valve, leads to its reference to the genus *Acrothele*, as it presents characters shown in a typical form of *Acrothele*, *A. subsidua*, White (Expl. and Surv. West 100th Merid., vol. iv, pt. 1, p. 34), from the Cambrian of Utah. On the list left by Professor Hartt, reference is made to specimen No. 342 as *Obolus (Discina) nitidus*, sp. nov. This specimen presents the characters of a ventral valve of *Acrothele*, and is of the form that the ventral valve of *A. Matthewi* would probably have, and although not associated with it at Saint John, I have little hesitancy in referring to it as the ventral valve of *A. Matthewi*. It is illustrated on plate i, fig. 4a.

Formation and locality.—Cambrian. Saint John formation, Saint John and Ratcliff's Millstream, N. B.

Genus OBOLELLA, Billings.

OBOLELLA TRANSVERSA, Hartt.

Plate i, figs. 5, 5a.

Obolella transversa, Hartt, 1868, *Acadian Geology*, Dawson, 2d ed., p. 644.)

"A very small, transversely oval species, from Coldbrook, Saint John."

The above is all the description by the author of the species and no figure is given, but, with the typical material used by him before me, there is little difficulty in recognizing the species.

It is closely allied to *Obolella sagittalis*, Salter, and Mr. Davidson's description of that species (*Geol. Mag.*, vol. v, p. 309, 1868) reads as though it were drawn from the Saint John specimens. Figures are given of the interiors of the two valves.

Obolella? miser, Billings (*Pal. Fos.* vol. ii, pt. 1, p. 69, 1874), is a closely allied species from the Saint John formation horizon. No figures accompany the description.

Formation and locality.—Cambrian. Saint John formation, Coldbrook, Saint John, N. B.

OBOLELLA, sp. undt.

What appears to be a second species occurs with the preceding. The form is more elongate, the surface is concentrically striated with fine

lines, and the interior appears to be less strongly marked by the muscular scars.

Genus ORTHIS, Dalman.

ORTHIS BILLINGSI, Hartt.

Plate i, figs. 1, 1b-d.

Orthis Billingsi, Hartt, 1868, *Acadian Geology*, Dawson, 2d ed., p. 644, fig. 223.

Description.—"Shell subquadrate to semicircular, broader than long; greatest width at the hinge-line; moderately convex; greatest thickness at about the middle; depressed in front. Hinge-line straight. Dorsal valve semicircular or subquadrate; depressed, with a shallow sinus running from the umbo to the front. Umbo not elevated above the hinge-area, which is very narrow, and marked by fine, parallel longitudinal striæ. Hinge-plate bearing two slight incurved internal processes. Ventral valve more arched than the dorsal, with a narrow, flat margin produced in the plane of the valve. Hinge-area triangular, concave, and marked with fine parallel lines. Umbo elevated above hinge-line about one-fourth of length of shell. Foramen triangular and of moderate size. Surface ornamented by about thirty prominent rounded, radiating plicæ, increasing in width towards the margin, becoming less elevated and slightly curved toward the ears, crossed by a number of distinctly marked, concentric, squamose lines of growth, and numerous fine concentric striæ. The radiating plicæ increase by bifurcation, which takes place at about one-third the distance from the umbo to the margin."

The figure accompanying the above description is that of a rather transverse ventral valve, on which the radiating costæ are unusually strong. They also bifurcate in a manner observed in but one other specimen in the collection. At first sight this shell will be separated as a distinct species from the variety, having sharp, somewhat distant ribs radiating from the beak, with finer ribs appearing between them on the cast, but other specimens occur where the two surface characters are shown on the same shell, and give the impression that we have a single variable species, the two extremes of which are shown in our figures 1, 1d, of plate i. The crowding together of the increased number of ribs on the costate variety gives the bifurcating character to the ribs or costæ.

The ventral valve of *O. Billingsi* is little elevated, in this respect being unlike other Cambrian species, and there does not appear to be any nearly-related species of *Orthis* in strata of Cambrian age. *Orthis Hicksi*, Salter (see Davidson's *Mon. Brit. Foss. Brach.*, vol. iii, p. 230), is the prevailing form in the Menevian of Wales, and in some of

its phases resembles *O. Billingsi*. Among the Swedish forms the latter may be compared with *O. exporecta*, Linnarsson* (Bihang till K. Svenska Vet. Akad. Handlingar. Band. 3, N:o. 12, p. 12, 1876).

Formation and locality.—Cambrian. Saint John formation, Ratcliff's Millstream and Saint John, N. B.

ORTHIS, sp. ?

Plate i, fig. 1a.

Associated with the preceding at Saint John, there is a small single dorsal (?) valve of a species of *Orthis* that appears to be distinct from *O. Billingsi*. A moderately well-defined median sinus is shown and the surface, as preserved in the cast, was somewhat finely ribbed. Professor Hartt refers to a new species of *Orthis* as not being sufficiently well represented to warrant its description, but gives another specimen, fig. 1c, plate i, as the form. This I consider as a variety of *O. Billingsi*, and the shell under consideration may only have the same position when a larger series comes to be studied.

Genus HARTTIA, n. gen.

This generic name is proposed for a unique little shell found in association with fragments of trilobites of the genera *Paradoxides* and *Ptychoparia*.

Description.—A small, oval, patelliform shell, having a low, broad ridge originating on the posterior (?) side of the interior that supports a subcordate shield-like expansion which extends out over the anterior (?) portion of the interior when we look down into the shell. The broad base of the ridge and the general character of the shield-like extension are well shown in the figure on plate i, fig. 3.

The character of the apex is unknown, as the only representation of the genus and species is in the form of a cast, showing the interior of the central portion and, around the margins, the cast of the apparently smooth outer surface.

The interior ridge and shield-like expansion is of a peculiar character, and unlike that of any described recent or fossil form known to me. It is so well marked that there is little hesitancy in proposing a new genus for its reception. The genus may be included in the *Calyptræidæ* nearest the genus *Crepidula*, if we compare the shield-like expansion with the shelf or shelly partition of *Crepidula*. However close or distant its relations to the latter, it certainly appears to be the representative of the *Calyptræidæ* type in the Cambrian, and adds another form, showing the differentiation of the invertebrate fauna in the oldest fauna yet known on the American continent.

The generic name is in honor of Mr. C. F. Hartt. With it I wish to

associate that of Mr. G. F. Matthew, the discoverer of the Cambrian age of the Saint John formation.

HARTTIA MATTHEWI, n. sp.

Plate i, fig. 3.

The characters of this species have already been given under the description of the genus.

The base of the shell, as shown in the specimen, measures 2.5^{mm} by 3.5^{mm}. It was probably a little larger, as the true margin is not to a certainty clearly shown.

There is no reference or record number attached to the specimen, and nothing is said of it in Mr. Hartt's notes as published by Mr. Dawson. A scratched outline around the specimen shows that it had been noticed, but whether by one of the collectors of the specimens or by Mr. Hartt is unknown.

Formation and locality.—Cambrian. Saint John formation. The character of the slate and the embedded fossils is similar to that of the material from Ratcliff's Millstream, and it was associated in the collection with specimens from that locality.

Genus *PALÆACMEA*, H. & W.

PALÆACMEA ? *ACADICA*, Hartt.

Plate i, fig. 6.

Discina Acadica, Hartt, 1868, *Acadian Geology*, Dawson, 2d ed., p. 644, Fig. 222..

Description.—"Shell elliptical in outline; sides more or less straight. Conical, but very depressed. Apex apparently central. Surface marked with a number of deep, concentric, irregular, sharp furrows, not always continuous, and often breaking up into smaller grooves, and all these seem at times to be impressed with lighter lines running nearly parallel with them. Of the large furrows from nine to ten can usually be counted. The whole surface of the shell is marked with a great number of delicate raised lines radiating from the summit to the circumference, and just visible to the naked eye."

An examination of several specimens of this species, including the types, leads me to think with Mr. R. P. Whitfield (*Bull. Amer. Mus. Nat. Hist.*, vol. i, p. 141, 1884), that it is not a true *Discina*, but probably a univalve shell, allied to *Palæacmea* or *Stenotheca*. The material in the collection is very poor and fragmentary; so much so that the generic reference is to be considered as merely provisional.

Formation and locality.—Cambrian. Saint John formation, Ratcliff's Millstream, N. B.

Genus HYOLITHES, Eichwald.

HYOLITHES ACADICA, Hartt.

Plate ii, fig. 5.

Theca Acadica, Hartt. Label on specimen.

Form an elongate triangular pyramid, tapering gradually and uniformly to an acute extremity. Transverse section subtriangular, about twice as wide as high; the lateral angles acute from compression in the specimens in the collection. Ventral face slightly arched; anterior margin extending forward in a semicircular subspatulate extension. Dorsal surface rather strongly convex. Aperture unknown, but undoubtedly oblique, judging from the character of the extension of the ventral side.

Operculum unknown.

Surface of shell marked by concentric lines of growth, parallel to the margin of the aperture, and exceedingly fine longitudinal striæ visible only by the aid of a strong magnifier.

In general form this species approaches very closely to *Hyolithes Americanus*, Billings (Can. Nat. n. ser., vol. vi, p. 215, 1872), but equally so to the Devonian *H. acilis*, Hall (Pal. N. Y., vol. v, pt. 2, p. 197,) except in the more rounded dorsal side.

Owing to the imperfect condition of preservation of the species illustrated from the Menevian group of Wales, it is difficult to make comparisons with them. Professor Hartt's specific name is retained, as the probabilities are that the form is different from the American Potsdam and Georgian species, although allied to *H. primordialis*, Hall (Sixteenth Ann. Rep. State Cab. Nat. Hist., p. 135,* 1863), and also the Menevian forms of the genus in Wales.

Formation and locality.—Cambrian. Saint John formation, Ratcliff's Millstream, N. B.

HYOLITHES DANIANUS, Matthews.

Plate ii, figs. 7, 7a, b.

Hyolithes Danianus, Matthews, 1884, MSS.

Form that of an extremely elongate rounded subtriangular pyramid that, in some examples, curves a little to one side as it becomes gradually attenuate towards the apex. Transverse section semielliptical; moderately convex on the ventral side and still more so on the dorsal. Ventral face flattened and almost concave along the center, rounding up on each side to the somewhat rounder lateral angles. Dorsal face not very strongly convex transversely. Form of aperture unknown.

Associated operculum broad oval, or subcircular in general form. The side corresponding to the ventral side of the shell curves regularly, but is not as convex as the opposite side. The umbo is situated

about four-fifths the distance from the dorsal margin, and extends laterally as a low, rounded ridge towards the rounded angles formed by the union of the ventral and dorsal sides of the operculum; just in front of these ridges a slight depression exists, also a depressed area back of the umbo, or towards the dorsal margin; the inner side shows a sharp ridge corresponding to the umbonal ridges on the outside, and also a sharp, short, elevated ridge between the ventral margin and the position of the umbo on the outer surface. The general body of the shell of the operculum appears to have been quite thin.

Surface of the shell marked by transverse, concentric undulations of growth that arch slightly forward on the ventral side. Outer surface of the operculum marked by fine concentric striæ and very fine, somewhat obscure, radiating striæ; inner surface with fine, slightly irregular, radiating lines or striæ.

There is considerable range of variation in the form of the shells of this species. In some the flattening of the ventral side is lost, and only a convex surface is shown, and the dorsal surface has a narrow longitudinal line on each side of the center. The curvature of the shell also varies considerably. A number of specimens of the operculum are associated with the shells, but none were observed attached before the mouth of the shell.

One unusually curved shell having a nearly round section, was labeled *Orthoceras*? n. sp., by Professor Hartt, as traces of what appear to be septa are shown. The distances between the septa-like partitions are unequal, and in other specimens this is seen to be owing to the filling of cracks across the tube.

This species recalls *Hyolithes cinctus*, Barrande (Syst. Sil. Bohême., vol. iii, plate ix, figs. 8-12), and the form of the associated operculum is also similar.

Formation and locality.—Cambrian. Saint John formation, Ratcliff's Millstream, N. B.

HYOLITHES MICMAC, Matthew.

Plate ii, fig. 6.

Hyolithes Micmac, Matthew, 1884, MSS.

Form that of an extremely elongate, rounded, subtriangular pyramid that becomes gradually attenuate towards the apex. The true transverse section is not preserved, owing to the crushing down of the shell, and appears to have been semielliptical or rounded subtriangular.

Form of aperture and operculum unknown.

Surface of the shell smooth externally; the interior is marked by fine, raised, longitudinal lines.

In form this species is not unlike *Hyolithes Danianus*, but the smooth outer surface and striated inner surface distinguishes it from that and also any other described species known to me.

Dimensions: Length of specimen 20^{mm}, width at aperture 4^{mm}.

Formation and locality.—Cambrian. Saint John formation, associated with *Microdiscus punctatus* at Ratcliff's Millstream, N. B.

Genus AGNOSTUS, Brongniart.

AGNOSTUS ACADICUS, Hartt.

Plate ii, figs. 2, 2a-c.

Agnostus Acadicus, Hartt, 1868, *Acadian Geology*, Dawson, 2d ed., p. 655.

Agnostus similis, Hartt, 1868, *Acadian Geology*, Dawson, 2d ed., p. 656.

Description.—"Head minute, transversely-elliptical, or subcircular; breadth and length about equal, convex but very depressed, outlines in front and on the sides slightly straightened. A narrow, flattened, and but very slightly elevated border goes round the front and lateral margins. This is separated from rest of shield by a narrow, shallow, flat space, or groove, which, on going posteriorly along the lateral margins, loses gradually in width toward the posterior angles of shield, which are rounded. Glabella a little less than two-thirds the length of shield, long elliptical, depressed convex, but more elevated than other parts of the shield, about twice as long as broad, bounded anteriorly and laterally by a sharp, rather deep groove concentric to the outer one above described. A well-marked transverse furrow, arching backwards, separates the anterior third of the glabella as a subcircular lobe. Posterior part of glabella rounded, but impressed on each side by a little lobe situated in the angle between the cheek-lobe and the glabella. These little lobes are about one-quarter the size of the anterior glabellar lobe. Cheeks of the same width throughout, and uniting in front of the glabella, being bounded by the two concentric grooves above mentioned. Posteriorly they are rounded; in width they are rather greater than the glabella. They are convex, more elevated along their inner margin, but sloping outward roundly and evenly. Glabella with its lobes project considerably beyond posterior margin. Surface smooth. Pygidium of this species (?) of about the same outline as cephalic shield. The posterior and lateral margins have a slight, raised border, separated from lateral lobes by a shallow but well-marked groove running parallel to the margin. This groove widens at the point where it bends to go forward along the sides in such a way as to encroach on and thin out the marginal fold, and, just before reaching the anterior margin, it narrows itself from the inner side so as to cause the lateral lobes to widen somewhat anteriorly. These are narrow, flattened, about half as wide as the middle lobe, narrowing to a point just behind the middle lobe, where they do not unite. The medial lobe is about five-sixths of length of pygidium, shield-shaped, flattened, convex, more elevated than the lateral lobe. Its anterior border is slightly concave in the middle. The lateral angles are rounded, and the lobe is contracted a little an-

teriorly. It is bounded by two deep and well-marked furrows, which join one another in the middle of the marginal furrow, forming a pointed arch. Medial lobe projecting farther forwards than the lateral ones. A little spine is situated on its mesial line about one-fourth its length from front. Surface smooth."

After a careful study of all the specimens in the collection, fifteen in number, I am unable to make out sufficient differences between the form described as *A. Acadicus* and that given as *A. similis*, to establish two species. There is a certain range of variation in the specimens as pointed out by Mr. Hartt, but that is so variable and owes its origin so largely to the condition of preservation of the various specimens that it is not evident that two species are typified.

Agnostus Acadicus is a type of the genus that occurs in the Menevian of Wales, as *A. Cambrensis*, Hicks (Quart. Jour. Geol. Soc., vol. xxvii, p. 400, 1871); in Norway, as *A. brevifrons*, Angelin (Pal. Scan., p. 6, 1852); in Bohemia as *A. integer*, Beyr. (Sil. Syst. Böhème., vol. i, p. 900, 1852); and in the American Potsdam horizon as *A. Neon*, Hall & Whitfield (Geol. Expl. 40th Par., vol. iv, p. 229, 1877). *Agnostus interstrictus*, White (Expl. and Surv., West 100th Merid., vol. iv, p. 38), from the Cambrian of Utah, is an almost identical species, differing principally in the postero-lateral angles of the pygidium.

Formation and locality.—Cambrian, Saint John formation, Saint John, N. B.

Genus MICRODISCUS, Emmons.

MICRODISCUS DAWSONI, Hartt.

Plate ii, figs. 3, 3a.

Microdiscus Dawsoni, Hartt, 1868. Acadian Geology, Dawson, 2d ed., p. 654.

Description.—"Cephalic shield semi-lunar, with thickened border crossed by numerous grooves running perpendicularly to the circumference. Glabella convex, narrow, rounded in front, conical and pointed behind, projecting beyond posterior border, without furrows or occipital groove. Cheeks convex, no eyes, and no traces of sutures. Posterior angles of shield with backward projecting spines. Pygidium subtriangular, with curved outlines, rounded in front and behind; middle lobe distinctly marked, and divided into six segments; lateral lobe also divided, furnished with a narrow border."

This is a beautiful little trilobite that is quite distinct from described species of the genus.

There are but three specimens in the collection, and none show the head and pygidium united.

Formation and locality.—Cambrian. Saint John formation, Ratcliff's Millstream, N. B.

MICRODISCUS PUNCTATUS, Salter.

Plate ii, figs. 1, 1a-c.

Microdiscus punctatus, Salter, 1864, Quart. Journ. Geol. Soc., vol. xx, p. 237, plate xiii, fig. 11.

Microdiscus punctatus, Whiteaves, 1878, Amer. Journ. Sci., 3d ser., vol. xvi, p. 225.

Microdiscus pulchellus, Hartt. Name proposed (No. 14) on list of fossils sent to Mr. J. W. Dawson.

Head semi-elliptical in outline, rather strongly convex, and bordered on the front and sides by a depressed furrow and raised rim, the furrow containing numerous short furrows perpendicular to the margin, as in *M. Dawsoni*, but not as strongly marked. The posterior border is strong back of the cheeks, and has the furrow continuing from the sides; a very narrow rim extends back of the glabella; eyes and facial suture entirely absent.

Glabella elongate conical, extending backward in a strong spine as long as the glabella in medium-sized specimens and nearly as broad at the base. In some examples the spine is shorter and smaller. The glabella rises above the level of the cheeks and is about three-fifths the length of the head, bordered by strong dorsal furrows that are connected in front by a straight furrow with the depressed groove within the anterior marginal border, perceptibly marked by two pairs of oblique glabellar furrows in some examples. Cheeks convex, prominent, strongly defined by the dorsal and marginal furrows.

Thorax unknown.

The pygidium, associated with the head of this species in great numbers, has the same general outline as the head. The narrow marginal rim is well defined all around, widest at the sides; anterior marginal furrow very distinct; median lobe elongate-conical, extending back nearly to the marginal groove; nine anchylosed segments are indicated by eight rather strong transverse furrows; lateral lobes strongly convex, no furrow appearing back of the anterior marginal groove.

Surface finely punctate, the punctæ being rather large as compared with the depth.

Dimensions of a rather broad head: Length, exclusive of spine, 3.5^{mm}; breadth, 5^{mm}; occipital spine, 3^{mm}; pygidium, length, 3.75^{mm}, breadth, 5^{mm}.

This is an abundant and well-marked species. Mr. Hartt evidently intended to describe it, as the name is given in his list, and selected specimens were mounted on blocks, one of which bears the name *Eodiscus pulchellus*, Hartt, n. g., n. sp. There is considerable variation in the relative proportion of the length and breadth of the head, also of the pygidium in different specimens, owing to an original variation, and also distortion from compression in the shales.

Mr. Whiteaves states that this species was first detected in the

Primordial slates of Saint John, N. B., by the late Mr. E. Billings. It has since been observed in rocks of the same age on the Kennebecasis River, N. B., where it was collected by Mr. G. F. Matthew.

The pygidium is very similar to that of *Microdiscus speciosus*, Ford (Amer. Jour. Sci., vol. vi, p. 137, 1873).

In comparing with the figures of *M. punctatus* given by Mr. Salter, it is observed that the nuchal spine of *M. punctatus* is longer and more slender, and the surface of the cephalic shield and pygidium are punctate, whereas, in the Saint John's specimens, the surface is smooth. In event of the two forms proving distinct on a comparison of specimens, I propose that Mr. Hartt's name, *M. pulchellus*, be given to the American species.

Formation and localities.—Cambrian. Saint John formation, Ratcliff's Millstream, N. B., and Manuel's Brook, near Conception Bay, Newfoundland.

Genus PARADOXIDES, Brongniart.

PARADOXIDES LAMELLATUS, Hartt.

Plate iii, figs. 2, 2a.

Paradoxides lamellatus, Hartt, 1868, *Acadian Geology*, Dawson, 2d ed., p. 656.

Paradoxides lamellatus, var. *loricatus*, Matthew, 1882, *Trans. Roy. Soc. Canada*, p. 105. plate ix, fig. 19.

Description.—"This is a small species distinguished from several others found with it by the presence of a number of sharp perpendicular laminæ on the anterior lobe of the glabella."

The types of this species consist of the casts of portions of two heads, both of which are illustrated on plate iii. It is, as stated by Mr. Hartt, distinguished from the associated species by the sharp perpendicular laminæ or ridges in front of the glabella.

Mr. Matthew has indicated a variety as *P. lamellatus*, var. *loricatus*. The elevated ridges on the front of glabella are variable in the two type specimens, and I should not consider the variation cited by Mr. Matthew as of sufficient importance to establish a varietal name, especially as he suggests the idea that the transverse ridges or interrupted elevated lines owe their origin to the condensation of the frontal area by transfer to the glabella; this would necessarily induce a great variation in the form and arrangement of the elevated lines in relation to each other, although they might retain their general relation to the frontal margin.

Formation and locality.—Cambrian. Saint John formation, Portland, a little northward of Saint John, N. B.

PARADOXIDES ACADICUS, Matthew.

Plate iii, fig. 3, 3a.

Paradoxides Academicus, Matthew, 1882, *Trans. Roy. Soc. Canada*, p. 103, Plate ix, figs. 16-18.

Mr. Hartt recognized several species of paradoxides and indicated them in his list, but did not name or designate the specimens; owing to

his not having time to work out the details (Acadian Geol., 2d ed., p. 657, 1868). One of these Mr. Matthew, in his valuable paper on the Paradoxides, has named *P. Acadicus*, describing it as follows:

"The anterior margin is regularly rounded and strongly arched backward. The marginal fold is moderately convex and about twice as wide at the extremity as in front of the glabella. The flat area is very small, and at the suture about as wide as the marginal fold.

"The glabella is about an eighth longer than wide. It expands regularly from the base to a point somewhat in advance of the fourth furrow, whence it is regularly rounded to the front.

"The glabellar furrows are all heavily cut. The first two cross the axis of the glabella; of these the first is arched decidedly backward, and is somewhat more heavily impressed in the outer than in the middle third. The second furrow strongly indents the glabella parallel to the transverse axis; it is more lightly impressed in the middle quarter than elsewhere. The two anterior furrows are in pairs. The third fails to cross the glabella by less than a third of the glabella's width; it begins within the margin of the glabella and is directed forward at an angle of about fifteen degrees. The fourth furrow begins on the edge of the glabella, and scarcely extends one-quarter of the way across it.

"The occipital ring is more than twice as long as wide; it is regularly convex and moderately arched vertically; a little behind the middle of the ring is a short tuberculous spine. In some of the largest heads the middle half of the ring is raised into a broad, rather flat, lobe which bears the spine. The occipital furrow is more strongly impressed in the outer quarter than in the middle.

"The posterior margin is moderately arched backward; the fold is regularly convex and moderately arched vertically. The furrow is scarcely as wide as the fold, and is rounded in the bottom.

"The fixed cheek is subtrapezoidal in form, is convex, and has an elevation at the posterior inner angle; it is strongly depressed in front, and the bounding furrows are distinct. The ocular lobe makes an open parabolic curve, and is prominently raised all round, but especially at the extremities. The curve of the posterior third of the ocular lobe in this species is more open than in that of the preceding species or its varieties.

"*Sculpture*.—Parallel raised lines appear only on the front half of the marginal fold, where there are about five. Elsewhere the surface of the test is covered with closely-set granulations visible to the naked eye.

"This neat little species is easily distinguished from all the preceding by its granulated surface, and by the absence of raised lines on the front of the glabella."

In the Hartt collection there is a specimen that adds materially to our knowledge of the species and the group of species to which it belongs, as fourteen segments of the thorax, the pygidium, and a portion

of the head are preserved. The head parts appear to be identical with the typical form described by Mr. Matthew, and are ornamented by the granulated surface, characteristic of the species. The thorax is very broad in proportion to its length, even though the fourteen segments preserved are not considered as entirely forming it. The allied Bohemian type, *Paradoxides rugulosus*, Corda (Syst. Silur. de Bohême., p. 347, plates ix and xiii), has but sixteen segments and the specimen under consideration shows no traces of more than fourteen; the anterior segments, however, are crowded down somewhat, and the head pushed to one side, which leaves the question of the actual number of segments unsettled. The median lobe is crushed together, but still shows that it had a width of 7^{mm} or 8^{mm} at the twelfth segment, the pleural lobe on each side of the same segment extending out 12^{mm} from the median lobe and terminating in slightly curved mucronate points of the same length on all the segments; posteriorly the median and lateral lobes contract, the pleural portion of the last four segments expanding and bending back so as to close down to the side of the pygidium; the pleural grooves are well marked and extend out about half way on the pleural lobe. The pygidium is the type of that of *P. rugulosus*, (*loc. cit.*), and corresponds to figure 19 of plate x of Mr. Matthew's paper more closely than any other.

Formation and locality.—The locality is not given with the specimen, but Mr. Matthew cites the species from Portland, N. B., and the lithologic characters of the shale correspond to specimens from that locality.

PARADOXIDES ETEMINICUS, Matthew.

Plate iii, figs. 1, 1a-g.

Paradoxides Eteminicus, Matthew, 1883, Trans. Roy. Soc. Canada, vol. i; p. 92, plate x, figs. 7-12.

Mr. Matthew gives a very elaborate description of this fine species and divides it into *P. Eteminicus* and four varieties, viz: *Suricoides*, *breuiatus*, *Quacoensis*, *Malicitus*, and *pontificalis*, the differences separating each appearing in the glabella, fixed cheeks, and the anterior lateral limbs. From our experience with the varying forms of *Olenellus* from Nevada, we should scarcely consider these, on the evidence given, as more than varieties of one species, as Mr. Matthew has done. A number of specimens of this species occur in the collection. One head (sp.?) indicates a trilobite 18^{cm.} or 20^{cm.} in length when entire, the portion of the head remaining being 6^{cm.} long.

For the purpose of illustrating the species of the Saint John fauna, known to me at present, several figures of *P. Eteminicus* are copied from Mr. Matthew's paper.

Formation and localities.—Cambrian. Saint John formation, Portland and Ratcliff's Millstream, N. B.

Genus CONOCORYPHE, Corda.³

CONOCORYPHE (Subgenus?) MATTHEWI.

Plate iv, figs. 1, 1a, b.

Conocephalites Matthewi, Hartt, 1868, *Acadian Geology*, Dawson, 2d ed., p. 646.*Conocephalites gemini-spinosus*, Hartt, 1868, *Acadian Geology*, Dawson, 2d ed., p. 653.

Description.—"Head semi-circular to semi-elliptical, more than twice as wide as long; front and lateral margins forming a regular curve; posterior margin nearly straight; posterior angles of shield flattened and rounded without spines; margin with a strong, round, rather narrow fold, which becomes narrower and lower towards the posterior angle of shield, where it disappears. This is separated from the cheek-lobes by a very deep, moderately-broad groove. This groove is arched forward in front by a large, semi-globose swelling, situated just in advance of the glabella, encroaching upon the marginal fold, causing it to be the thickest on each side of this prominence.

"The posterior margin is also folded, but the plait is more or less inclined backwards. The fold is narrow near the occipital ring, but grows more prominent and gains in width towards the posterior angle, but, like the anterior fold, it disappears at that point. Its course is not straight; at about half the distance of the outer angle it bends slightly backwards and downwards and then forwards slightly to disappear on the flattened or rounded angle of the shield. This fold is separated from the cheek-lobes by a groove shallower and broader than the marginal one, which it resembles, by expanding gradually into the flattened space of the outer angle. This groove follows a course parallel to the fold which it accompanies. Length from occipital furrow, about half that of head.

"Glabella subconical, longer than wide, strongly rounded in front, and about half as wide anteriorly as posteriorly; length about that of whole shield, strongly convex, but less elevated than the cheek-lobes, bounded laterally and anteriorly by deep grooves, the anterior being not so deep as the posterior. The sides of the glabella are impressed and divided into lobes by three pairs of deep lateral glabellar furrows. Those of the posterior pair are the longer and more deeply impressed. These furrows begin abruptly at a point somewhat in advance of the middle of the longer diameter of the glabella, and directed backwards at an angle of about 45° to the antero-posterior diameter of the shield, disappear abruptly without gaining the medial line, usually extending a little more than the third of the distance across the glabella. Those of the median pair begin also on the bounding groove very abruptly, only a little in advance of the posterior pair, but they are usually not so oblique, and extend on each side not more than a quarter of the distance across the glabella. The distance between the outer extremity of

³ See note on this genus under remarks on the genus *Ptychoparia*.

the median and anterior furrows is somewhat less than between those of the median and posterior, and these but slightly impress the sides of the glabella, and occasionally are scarcely visible. The anterior lobe is about as wide as the one which follows it.

"The occipital furrow is deeply cut in the outer third of its length and strongly directed forwards; in the middle third it is not so deep and is quite strongly arched forwards. The occipital ring is narrow, strongly convex, and vertically arched, the sides being more or less narrowed, turned downwards and forwards, being projected obliquely more or less across the posterior marginal cheek-groove towards the inner posterior angle of cheek-lobe. The ring projects backwards beyond the margin, but not beyond the posterior lateral angle of shield. The middle part is produced into a very short conical tubercle-like spine, directed slightly backwards. The cheek-lobes are strongly gibbous, and very regularly arched, the convexity being stronger anteriorly. A narrow, distinct, wavy ocular ridge begins on the cheek-lobe, just opposite the anterior part of glabella, and, thinning gradually out and arching, at first slightly forwards, curves round and is directed towards the outer angle of cheek-lobe, but it usually vanishes before reaching that point. From its anterior outer side it throws off a very numerous set of fine, bifurcating, raised lines of ridges. These lines are directed outward from the primary line at a rather acute angle, and appear to bifurcate several times. This ocular ridge is thickened at its commencement, but is not so strongly marked at that point as in *C. Baileyi*. It is also more arched forward than in the latter species. The whole outer surface of the shield is covered by innumerable, close-set, raised points or granulations, just visible to the naked eye, but very distinct under the lens, appearing in the impression of the shield as minute punctures. These appear to be more distinct on the convex portions of the shield. The raised margins, cheek-lobes, glabella, occipital ring, as well as the lobe just in advance of the glabella, bear sparsely-sown, minute, short spines, which give to the surface a distinct granular appearance. These are always wanting in the furrows and on the cheek-lobes, are more crowded on the outer halves of the cheek-lobes. They are true spines, but usually appear as granulations on the casts.

"In very young specimens, a line in diameter, the shield is semicircular, the cheek-lobes are extremely gibbous, and very much more convex than the glabella, and the preglabellar lobe is very conspicuous."

The above description gives all the characters of the adult head of this species as shown in the specimens contained in the Hartt collection. A number of small heads show embryonic features, but as Mr. Hartt did not describe these and Mr. Matthew is at work on the species and its stages of development, we will await the appearance of his paper.

Mr. Linnarsson unites *Conocoryphe coronatus*, Barr. (Syst. Sil. de Bohême., vol. i, p. 424, plate xiii, figs. 20-26), *C. exsulans*, Linnarsson (Sv. Geol. Unders. Afh., Ser. C., N:o. 35, p. 17, 1879), *C. solvensis*,

Hicks (Quar. Jour. Geol. Soc., vol. xxvii, p. 400, plate xvi, fig. 8, 1871) and *C. Matthewi*, Hartt, as a natural group chiefly characterized by the boss or elevation in front of the glabella. He speaks of *C. (Elyx) laticeps*, Ang. (Pal. Scan., t. 5, figs. 2-3, 1854), as the nearest allied from among Swedish species, and there appears to be good reason for placing it very close to, if not in the *C. coronatus* group.

Mr. Córdá proposed the generic name *Ctenocephalus* (Prodrom. Mon. böhm. Trilobiten, p. 142) for this type of the *Conocephalidæ*, and in many respects it is a convenient subgeneric term.

I know of no American species from the Potsdam or Georgian horizons that will fall within the group, although a species from the Georgian horizon, in Central Nevada, *Ptychoparia Linnarssoni*, Walcott (Pal. Eureka Dist., in press), has a boss in front of the glabella much the same as that in *C. coronatus*. The presence of large, free cheeks, well marked eyes, and facial sutures, places the species in the second division of the *Conocephalidæ* under the genus *Ptychoporia*, or a subgenus of the latter.

Mr. Hartt describes a second species of this group under the name *Conocephalites gemmini-spinosus*, as follows: "Resembles *C. Matthewi*, but with wider and less elevated marginal folds; cheek-lobes much more gibbous and semi-ovoid, &c., sparsely sown with minute spines, grouped two and two. Rare, at Saint John." This species does not appear on the list of numbered specimens, and I fail to find any specimens that differ from the typical forms of *C. Matthewi* sufficiently to warrant a separate specific name. Under the circumstances it appears best to place the name as a synonym of *C. Matthewi*, on the grounds of imperfect description, no illustration, no labeled type specimen, or a form in the collection that can be recognized as the one referred to by the author. Specimen No. 91 is referred to as *C. Matthewi* var. ?. This is a well-marked variety in its surface characters, as the scattered tubercles of *C. Matthewi* are crowded together and give the glabella, cheeks, frontal lobe, and margins a granulated appearance quite unlike *C. Matthewi*. The ocular-like ridges are also lost in the crowding together of the tubercles; fig. 1 b., pl. iv.

Formation and localities.—Cambrian. Saint John formation, Ratcliff's Millstream, Saint John and Portland, N. B. The variety (= *granulata*) is labeled Cold Brook (= Portland, on authority of Mr. Matthew).

CONOCORYPHE WALCOTTI, Matthew.

In a letter received from Mr. G. F. Matthew May 22, 1884, written since the preparation of this paper, he states that he has found a species of *Conocoryphe* in the Saint John formation, characterized by transverse bars on the glabella, a granulated but not tuberculated surface, and other features separating it from the other species of the genus. For this species he proposed the name *Conocoryphe Walcottii* in

a paper "On the Conocoryphidæ of the Saint John group, with remarks on Paradoxides," read before the Royal Society of Canada, May, 1884.

Subgenus *SALTERIA*, n. subgen.

Dr. Henry Hicks, in his description of *Erinnys venulosa*, refers the species to Salter (Brit. Assoc. Rep., 1865), where we find the name used and the relations of the genus to Harpides pointed out, and the fact stated that it has a great number of free segments and no facial sutures and probably no eyes. The description of *Erinnys venulosa* (Quart. Jour. Geol. Soc., vol. xxviii, p. 177), is of the type species, and gives that of the genus as far as known.

Description.—Ovate in form, being widest in front, and surface depressed. The largest specimens indicate a fossil at least $3\frac{1}{2}$ inches long.

"Head semicircular, margined all round, but with no posterior spines wider than the body. Glabella small, occupying only about two-thirds of the length and about one-fifth of the width of the head; pyramidal in shape, slightly raised, and indented by three pairs of furrows, the hinder ones reaching backwards nearly to the neck-lobe, and marking off triangular lobes on each side.

"There are no distinctly-marked eyes or facial sutures, but a tolerably strongly-raised ridge strikes off on each side from opposite the upper glabellar lobes towards the posterior angles, reaching nearly two-thirds of the distance across. From these ridges lines strike off in each direction, especially forwards, dividing and subdividing in their course and giving a veined character to the whole surface.

"Thorax composed of 24 rings; axis narrow, convex, and tapering towards the tail; pleuræ compressed, grooved, and, including the spines, more than twice as long as the rings of the axis; spines bent backwards from the fulcrum, at which part the surface becomes suddenly raised into a sharp, transverse ridge.

"The tail is semicircular, and has a tolerably strong axis, composed of four segments. The lateral lobes are marked by four moderately well-defined ribs."

This is certainly a very remarkable form, and is, as stated by Mr. Salter, related to Harpides; still it does not appear to be congeneric with it.

The first generic use of the name *Erinnys* of which we have record, was by Mr. Schrank (Faun. Boica, vol. ii. pt. 1, p. 152, 1801), for a genus of Lepidoptera. Mr. Schrank spelled the name "Erynnis." Mr. Agassiz suggested in his Nomenclator Zoölogicus, 1846, that it be changed to *Erinnys*. The name was again used by Mr. J. Thompson (Arch. Ent., vol. i, 1857) for a genus of Coleoptera. In 1865 Mr. Salter proposed it for the genus under consideration, and in 1867 it was again proposed for a genus of Coleoptera by Mr. Oustalet (Scudder Index Univer., p. 115). As Mr. Salter's name was anticipated, it becomes

necessary to replace it, and the name *Salteria* is proposed in honor of the distinguished paleontologist. The generic description, as far as known, is essentially that of *Salteria venulosa*. With it we may place *S. Baileyi*, as it is an almost identical species, as far as can be determined from the head and pygidium.

CONOCORYPHE (SALTERIA) BAILEYI, Hartt.

Plate iv, figs. 3, 3a; pl. v, figs. 7, 7a.

Conococephalites Baileyi, Hartt, 1868, *Acadian Geology*, Dawson, 2d ed., p. 645.

Description.—"Head transversely semi-elliptical, half as long as wide; anterior margin in front more or less straight; posterior margin quite straight; posterior angles of cheeks slightly rounded and unfurnished with spines; facial suture never visible; anterior margin of shield with a narrow, very elevated border, which is widest and most elevated in front, and grows narrower and lower posteriorly, becoming obsolete, or nearly so, at the posterior angle of the shield. This border is separated from the other part of the shield by a deep, rather wide furrow, which is deepest in front, but grows shallower as the anterior border loses in height going posteriorly. General form of shield convex, but much depressed; glabella more depressed than the cheek, subtriangular, depressed convex, broadly rounded in front, and separated from the cheeks and front by a deep, well-marked furrow; width at base equal to length, which last is about seven-tenths that of shield; very much narrowed in front. Lateral bounding furrows inclined to one another at such an angle as would cause them to meet if produced to the middle of the front margin of head. Occipital furrow deep and well marked, slightly arched forward in middle, and curving downward and forward, growing narrower at the extremities, and less deeply cut than the bounding furrow of the glabella. No lateral glabellar furrows, or very slightly marked, ever seen on casts. Occipital ring more elevated and rather wider in the center; bent forward at the sides; narrow, with a very low, spine-like tubercle in the center. Posterior furrow moderately deep and wide. Sides of shield bent slightly downward. Posterior angles flattened. Cheeks subtriangular, bounded by the straight dorsal furrow, the straight groove which separates them from the glabella and the curved marginal furrow. They are more convex or gibbous than the glabella, sloping gently toward the marginal furrow, but steeply to the other bounding grooves. In the cast they are marked on the edge of the bounding groove of the glabella at the points where the straight sides of the latter begin to curve around the front by two small, low, but well-marked ocular prominences, from each of which extends a slight ocular ridge, with a more or less outward curve toward the posterior angle of the shield, but usually losing itself at about half the distance in a system of delicate ramifications, which may often be traced to the posterior angles of the cheek lobes. Like ramifications are thrown

off for the whole length of the ridge from its anterior side, and these occupy the surface of the cheek lobes in front of the line. The surface of the cast sometimes appears granular, but the mould is always smooth, and the outer surface of the shield was unfurnished with tubercular or granular ornamentation. The posterior border on each side of glabella is very elevated in the middle, and loses height thence each way. Cephalic shield sometimes an inch and a half in width."

On one specimen referred to this species the left postero-lateral angle of the head shows a short, slender, rounded spine, a feature not mentioned in the original description, and a short facial suture cuts off a slender strip of the postero-lateral side of the cheek, carrying the spine with it.

The resemblance between the head of this species and that of *C. (Salteria) venulosa* is very striking, the greatest difference appearing in the presence of a suture line and postero-lateral spine. I suspect, however, that, as in the case with *C. (S.) Baileyi*, the free cheek and spine are broken away in *C. (S.) venulosa*, and have not been observed, owing to that. One specimen of *C. (S.) Baileyi* preserves twelve segments of the thorax and the pygidium. The latter is of the type of that of *C. (S.) venulosa*, but the thoracic segments vary considerably at the genal angle of the pleural lobes and in the rounded instead of falcate terminations of the pleuræ. The true number of segments in the thorax is unknown.

Formation and locality.—Cambrian. Saint John formation. Ratcliff's Millstream, N. B.

CONOCORYPHE ELEGANS, Hartt.

Plate iv, figs. 2, 2a, b.

Conocephalites elegans, Hartt, 1868, *Acadian Geology*, Dawson, 2d ed., p. 650.

Description.—"Head or cephalic shield semi-circular or semi-elliptical, more than twice as broad as long, nearly straight behind; anterior border with a very strong fold, separated from the rest of the head by a deep groove. This fold is widest and most elevated just in front of the glabella, where it is sometimes the tenth of an inch in width. At this point the groove bends abruptly and angularly, and arches forward on each side so as to encroach on the marginal fold and cause it to disappear at about half the distance between the middle point in front and the posterior angles of shield. The posterior marginal folds are very thin, most elevated in the middle, and sloping each way towards the occipital ring and posterior angles of shield. The axis of the outward half is more and more inclined backward from the perpendicular towards the posterior angles, which are rounded, more or less flattened, and with out backward projecting spines. The grooves separating the posterior fold from the cheeks are very deep, and are slightly directed forward. Length of glabella about sixth-tenths of antero-posterior diameter of

shield, a little wider at base than long, and less than half as wide anteriorly; triangular, with anterior part rather broadly rounded, highly inflated, and bounded by deep grooves, which in front join in with the anterior marginal groove. There are three pairs of glabellar furrows. Those of the posterior pair impress deeply the sides of the glabella, are strongly curved backwards, and scarcely reach a third of the distance across each side. The second and third pairs only just impress in like manner the sides of the glabella. Those of the second pair are curved backward, and extend about a quarter of the distance across the glabella. Those of the third pair are very short, and appear to be parallel with the transverse diameter, but they are not always distinct.

Occipital furrow deep, slightly arched forward in the middle, and with the ends turned in the same direction; occipital ring of moderate width; the middle is produced into a spine often more than a quarter of an inch in length. This spine is more or less strongly directed backwards. The cheek-lobes are very gibbous, more so than the glabella. Their posterior border is so strongly impressed by the posterior furrow that it arches slightly over it. The surface of the convex part of the shield is ornamented by very fine, close-set granulations, distinctly visible to the naked eye, and by a set of delicate little tubercles more sparsely sown."

This distinct and finely ornamented species may be compared with *Conocoryphe bufo*, Hicks (Quart. Journ. Geol. Soc., vol. xxv, p. 52, 1869). In the form of the head, frontal margin, and glabella, the character of the granulose surface and absence of facial sutures and eyes, as far as known, they are very much alike. We know of the presence of the postero-lateral spines of the head in *C. elegans*, but not the occipital spine in *C. bufo* which is present in *C. elegans*. *Conocoryphe Dalmani*, Angelin (Pal. Scan., p. 63, pl. xxxiii, fig. 16, 1854), belongs to the same group of species and is very closely related to them. Linnarsson speaks of *C. tenuicincta*, Linn., *C. emarginata*, Linn., *C. Dalmani*, and *C. bufo* as forming a natural group (Sv. Geol. Unders. Afh., Se. C. N:o 35, p. 20, 1879), and with these we add *C. elegans*, as it is a similar type and nearly identical with *C. bufo* and *C. Dalmani*.

Formation and locality.—Cambrian. Saint John formation, Ratcliff's Millstream, N. B.

Genus PTYCHOPARIA, Corda.

Ptychoparia Corda, 1847, Prodröm. Mon. böhm. Trilobiten, p. 141, Abh. den K. Böhm. Gesells. den Wissenschaften.

= *Conocephalus* Zenker, 1833 (in parte); *Solenopleura*, Angelin, 1851 (in parte); *Crepicephalus*, Owen, 1852 (in parte); *Conocephalites*, Barrande, 1852 (in parte).

In looking up the history of the generic names *Conocephalus*, *Conocoryphe*, *Ptychoparia*, and *Conocephalites*, we find that *Conocephalus* was first proposed by Mr. Zenker in 1833, with *C. Sulzeri* as the type, a trilobite without eyes and having a peculiar direction to the facial sutures of the head.

In 1839 Mr. Emmrich described, as a distinct species from *C. Sulzeri*, *Conocephalus striatus*, referring it to the same genus, although it has well-developed eyes and a direction of the facial sutures unlike that of *C. Sulzeri*.

Mr. Corda, in 1847, observed that *C. Sulzeri* and *C. striatus* represented two generic groups, and as the name *Conocephalus* had been preoccupied for a genus of insects in 1812, he proposed two generic names for the two types, *Conocoryphe* being given to *C. Sulzeri* and *Ptychoparia* to *C. striatus*. This division appears to me to be one demanded by the characters of the two types, and I fully indorse the opinion of the late Mr. F. B. Meek (Sixth Ann. Rep. U. S. Geol. Surv. Terr. 1872, p. 487), that Mr. Corda's names should be adopted and the subsequent name, *Conocephalites*, proposed by Mr. Barrande in 1852, treated as a synonym. Mr. Corda used the same type species in proposing the genus *Conocoryphe*, and there does not appear to be sufficient reason for refusing to adopt the name. Of the value of the genus *Ptychoparia* paleontologists may differ, but if we unite before our minds the characters of *Ptychoparia striata* and *P. Emmrichi*, the types referred to by Mr. Corda, and then bring together the group represented by *Conocoryphe Sulzeri*, *C. coronatus*, *C. exsulans*, Linnarsson, *C. solvensis*, Hicks, and *C. Matthewi*, Hartt, in the same manner, we will observe differences that, to me, appear to be of undoubted generic value. This division may be carried still further if we adopt Mr. Corda's third division of *Conocephalus*, *Ctenocephalus*, as a subgenus of *Conocoryphe*, and place *C. coronatus*, *C. Matthewi*, *C. exsulans*, and allied species under it. From Mr. G. F. Matthew's study of *C. Matthewi* I am very much inclined to adopt *Ctenocephalus* in that manner.

Mr. Meek (*loc. cit.*) thinks that in adopting this view the generic name *Ptychoparia* will necessarily be applied to nearly all the species of the *Conocephalidæ* described from American rocks. With some considerable exception this is true, and especially so of the group placed under the generic name of *Crepicephalus*, by Messrs. Hall and Whitfield (Geol. Expl. Fortieth Par., vol. iv, p. 209, 1877). They revived the genus which was proposed by Mr. Owen (Geol. Surv. Iowa, Wis., and Minn., p. 576), making *C. Haguei* the first species.

For the purpose of placing before all the means of comparing the types of the two genera, they are figured side by side on plate v. *Ptychoparia striatus*, the type of the genus, has two more segments in the thorax than *P. Haguei*, but that is not a character of generic value of itself. Of Mr. Owen's type of the genus *Crepicephalus*, *C. Iowensis*, only the head is known, although the pygidium usually associated with the head is peculiar and might give rise to a subgeneric group, but not as defined by Mr. Owen or Messrs. Hall and Whitfield.

Ptychoparia Emmrichi, Barr. (Syst. Silur de Bohême, I, p. 428, plate ii, Figs. 2-6), the second species arranged under the genus by Mr. Corda, differs in having the central portion of the head between the sutures in

front of the eyes narrower than in *P. striata*, a feature quite prominent in the species from the Potsdam group in Wisconsin, etc. The pygidium is also more like that of *P. Haguei*, and the pleura have less angular extremities. If the student will compare fig. 4, plate ii (Syst. Silur. de Bohême, vol. i, 1852), *P. Emmrichi*, with fig. 7 of plate xiii of the same work, I think that he will scarcely wish to place the two species in two subgeneric groups. If not, there appears to be no other way but to place *Crepicephalus* as a synonym of *Ptychoparia* for all species except *P. (Crepicephalus) lowensis*, where it may be used as a subgenus on account of the peculiar pygidium. The genus *Loganellus* Devine (Geol. Canada, Pal. Foss., vol. i, p. 200), is of the same type as *Ptychoparia Emmrichi*, and is considered by Messrs. Hall and Whitfield as identical with *Crepicephalus* = *Ptychoparia Haguei*. *Solenopleura* Angelin (Pal. Scan., p. 26) and *Liostracus* Angelin each approach this group. *Liostracus* represents the forms with the glabella devoid of furrows and the presence of ocular ridges on the fixed cheeks, and is a convenient subgeneric group. *Solenopleura* appears to be of the same character as many of the species placed under the genus *Bathyrurus* by Mr. Billings, and I think can be used for such forms as *Bathyrurus gregarius*, Billings (Pal. Foss., vol. i, p. 363), and nearly all the species referred to the genus *Bathyrurus* from the Cambrian. The figure of the type species of *Solenopleura* is copied on plate vi, fig. 3.

Among the species from the Saint John formation *Ptychoparia Robbi* approaches most nearly to the typical forms of the genus *Ptychoparia*.

PTYCHOPARIA ROBBI, Hartt.

Plate vi, figs. 1, 1a.

Conocephalites Robbi, Hartt, 1868, *Acadian Geology*, Dawson, 2d ed., p. 648.

Conocephalites formosus, Hartt, 1868, *Acadian Geology*, Dawson, 2d ed., p. 654.

Description.—"Head without movable cheeks, of moderate size, depressed convex, slightly arched in front, where the width is considerably less than behind; length about equal to breadth in front.

"Glabella ovate conical, sides straight, and dorsal furrows so inclined as to meet if produced in middle part of anterior margin; very convex; more elevated in the middle; posterior furrows reaching about one-third of the way across the glabella, directed strongly backwards, and reaching nearly to the base of the glabella; middle furrows less distinctly marked, short, not so oblique as first; anterior very short, appearing only as little pits or depressions on the sides of the glabella.

"Occipital ring narrow, convex, widest in the middle, narrowing towards the sides, which are turned forward, giving to it a crescent shape. Occipital furrow deep and well developed, widest in the middle, where it slightly impresses the base of the glabella; narrow and slightly bent forward at the ends. The ring bears a little, short, conical, tubercle-like spine in the middle, directed slightly backwards.

"Fixed cheeks, frontal limb one-third to one-fourth of whole length of head, with a narrow, high, convex border, inside of which is a moderately deep furrow; cheek-lobes depressed, convex, meeting in front, rising abruptly from the deep dorsal furrow, on the borders of which they reach their greatest elevation, which, however, is not equal to that of glabella, and sloping thence roundly towards the sides and front. The posterior limb bears a deep, wide, furrow, which widens somewhat near extremity. The marginal fold is very narrow and of little prominence, and widens a little in the outer half. The posterior margin bends slightly backwards at extremity of limb, which is rounded."

On comparing the type specimens of *P. Robbi* and *P. formosus*, and also a number of specimens of *P. Robbi*, I am unable to obtain good specific differences between them. The range of variation is slight and the two extremes are intimately united by specimens possessing the characters of each in a more or less fully developed condition. *P. formosus* appears to have been founded on compressed specimens of *P. Robbi*.

The representative type of *P. Robbi* occurs in the Menevian of Wales as the very closely related species *Ptychoparia* (= *Conocoryphe*) *applanata*, Salter (Quart. Jour. Geol. Soc., vol. xxv, p. 53, pl. xxv, figs. 1, 2, 4, 5). In *Ptychoparia* (= *Solenopleura*) *cristata*, Linnarsson (Afdrag ur Geol. Foreningens, i Stockholm Förhandl. 1877, N:o. 40, Band. iii, N:o. 12, p. 370), from the Paradoxides beds of Sweden, we find an allied species, and Mr. Linnarsson compares it with *P. Emmerichi*, the nearest representative of the type in Bohemia.

Formation and locality.—Cambrian. Saint John formation, Ratcliff's Millstream, N. B.

PTYCHOPARIA OUANGONDIANA, Hartt.

Plate v, figs. 4, 4a-f.

Conocephalites ouangondianus, Hartt, 1868, Acadian Geology, Dawson, 2d ed., p. 651.

Description.—"Head without movable cheeks; strongly convex in outline, somewhat subangular in front; much narrower in front than behind, where width is greater than the length; width in front nearly equal to length; anterior margin wide, with a strong fold, whose axis is strongly inclined forwards, so that it presents a short, steep, convex slope forward, and a long, concave slope in the inner side, being much less elevated than glabella or fixed cheeks. Glabella long, ovate-conical, nearly twice as wide posteriorly as in front; very convex, slightly subangular at the middle; sides straight, inclined to one another so as to meet in the middle of front margin if produced; rounded in front; casts sometimes showing three pairs of short, raised, transverse lines on the sides of the glabella, occupying the position of the ordinary glabellar furrows; of these the two posterior are directed obliquely backwards. In some specimens there seems to be a fourth pair in ad-

vance of the other, represented by little tubercle-like processes situated on the side of the glabella in front, just where the sides curve to the front. Glabella very much more convex than fixed cheek. Occipital ring strongly arched upward, and separated from glabella by a well-marked groove; middle of posterior margin produced backwards in a short conical spine. Fixed cheeks highest along dorsal furrow, towards which they pressed abrupt round slopes, while their general surface slopes gently and quite evenly towards front of sutures. The dorsal furrows are confluent in front with the flat margin, so that the cheek-lobes do not meet in front. They are highest along the straight dorsal furrows, but where they bend to go round the anterior extremity of glabella, the cheek-lobes narrowing and curving towards each other, gradually sink away and disappear in the front flattened space. The ocular lobes are very well developed, forming subsemicircular lappet-like lobes, curved strongly upwards, and situated about opposite the center of the head. An ocular ridge, low and rounded, but very prominent, runs from anterior margin of ocular lobes, with a curve almost parallel with front margin of shield, but slightly divergent from it to the dorsal furrow, which it gains at a point considerably back of front of glabella, and where the straight part of the dorsal furrow bends to go round the front. Posterior limb short and broadly rounded. Post-marginal furrows less deep than dorsal; wider; marginal fold narrow and moderately prominent; shield strongly arched transversely; surface smooth."

This species is more fully represented by the central portion of the head than any other in the collection. The range of variation appears to have been small originally, but the distortion by lateral and vertical compression gives it a variety of forms. Three of these are illustrated.

A small head that appears to be uncompressed looks very much like that of *P. (Solenopleura) cristata*, Linnarsson. (See description of *P. Robbi*.) Mr. Hartt speaks of this species as rather uncommon at Ratcliff's Mill stream, but on examining all the duplicate material we find upwards of forty specimens. From the character of many of the specimens it appears quite probable that some of this material was not before him when he wrote the notes on the species.

Formation and locality.—Cambrian. Saint John formation, Ratcliff's Millstream, N. B.

PTYCHOPARIA OUANGONDIANA, var. AURORA, Hartt.

Plate v, fig. 5.

Conocephalites aurora, Hartt, 1868, *Acadian Geology*, Dawson, 2d ed., p. 653.

Description.—"Resembles *C. ouangondianum*, but differs in wider head, more depressed; anterior margin more broadly rounded, and border more strongly reflexed and elevated."

To me the distinctive character between this species and *P. ouangondiana* is in the form of the glabella. Compression and distortion may give the depressed broader form and reflexed rim, but not entirely the subquadrate glabella, that appears to be a feature of original varietal importance. With a large series of specimens of this form showing its variations, the tendency will be to deprive it even of a varietal name and unite it directly with *P. Ouangondiana*.

Formation and locality.—With the preceding species at Ratcliff's Millstream, N. B.

PTYCHOPARIA QUADRATA, Hartt.

Plate v, fig. 1.

Conocephalites quadrata, Hartt, 1868, *Acadian Geology*, Dawson, 2d ed., p. 654.

Description.—"Head minute, transversely oblong, twice as long, slightly curved in front, straight behind, very flat; a narrow elevated fold, convex in front, concave behind, and somewhat inclined backward, goes round the margin."

There appears to be but one specimen representing this species in the collection. The strongly-marked subquadrate glabella distinguishes it at once from the associated species except *P. ouangondianus*, var. *aurora*, from which it is scarcely separated by the character of the frontal rim and the stronger ocular ridges. The entire length of the head is but two millimeters.

Formation and locality.—Cambrian. Saint John formation. Portland, a little northward of Saint John, N. B.

PTYCHOPARIA ORESTES, Hartt.

Plate v, fig. 3, 3a.

Conocephalites orestes, Hartt, 1868, *Acadian Geology*, Dawson, 2d ed., p. 649.

Conocephalites Halli, Hartt, 1868, *Acadian Geology*, Dawson, 2d ed., p. 654.

Description.—"The head-shield of this species without movable cheeks is of medium size, length about equal to breadth in front, or to two-thirds width behind; margin arched moderately in front, with a rather wide, low border fold, widest in front, narrowing toward the sides, separated from the rest of the head by a shallow groove. Glabella long, ovate, conical, or cylindrico-conical, extremely convex, wider behind than in front, where it is rounded. The sides are straight, and so inclined to one another as to meet, if produced, at a distance in advance of margin in front about equal to the distance of that line from glabella. The glabella is flattened on the sides and never regularly convex. There are three pairs of furrows, which lightly impress the sides of the glabella, and of which traces are not always distinctly preserved, and they are apt to be seen best in slightly distorted specimens. Dorsal furrow narrow, deep, and sharply cut; occipital ring widest in the middle, narrowed from behind at the sides, separated from glabella by a

distinct furrow. Bears in the middle a minute tubercular spine pointing upwards. Fixed cheeks strongly convex, but much less so than the glabella, meeting in front with abrupt slopes toward dorsal and posterior marginal furrows, but with gentle rounded slopes toward sides and anterior groove. Ocular ridges, marked as lightly raised lines, originating at the dorsal furrow some distance behind the front of the glabella, and rising obliquely upwards and backwards to ocular lobes, which are small and semi-lunar, folded considerably upwards, and are situated just opposite middle of head; width between ocular lobes about equal to the width in front. Behind the eye the suture describes a long open sigmoid curve, which is continued inward somewhat so as to give the limb a rounded outline, and make the cheek here about one-third wider than at the eye. Posterior margin of cheeks with a slight fold, more prominent in the middle; outer half of this margin is arched backwards. Whole head arched slightly forward vertically."

The relations of this species are with both *P. Robbi* and *P. Ouangondiana*. From the former, the character of the frontal rim and the more elongate glabella serves to separate it, and from the latter the rounded rim-like frontal border instead of the broader flattened margin. The relations of *P. Orestes* and *P. Ouangondiana* are very close.

Specimen No. 59 is recorded in M. Hartt's list as *Conocephalites Halli*, and that name is scratched on the slate beside the specimen. The figure in the Acadian Geology (Fig. 227) was certainly not drawn from this specimen, but the description appears to have been.

Description.—"Well separated from all others by its very convex, narrow, and long glabella, ovate, or cylindro-conical, as well as by its strongly-rounded sub-angular outline in front, and by its peculiar anterior marginal fold."

I have studied the type specimens and also the representations of *P. Orestes* and Mr. Hartt's *C. Halli* in the collection, and it appears to be impossible to find characters that are persistent in a series of individuals to separate them as distinct species.

Formation and locality.—Cambrian. Saint John formation, Ratcliff's Millstream, N. B. The type of Mr. Hartt's *C. Halli* is from the same locality.

PTYCHOPARIA ORESTES, var. THERSITES, Hartt.

Plate v, fig. 2.

Concephalites Thersites, Hartt, 1868, Acadian Geology, Dawson, 2d ed., p. 653.

Description.—"Differs from the last (*Conocephalites Aurora*) and also from *C. Ouangondianum* in the front margin being broad and flat, and bordered by a low, narrow, flattened fold or ridge, &c. Glabella in the cast has three pairs of very short raised lines on the sides."

This species appears to have been founded on a single somewhat distorted head, exclusive of the free cheeks. Its relations to *P. Ores-*

tes are very close, and I had placed it with *C. Halli* under *P. Orestes* in a preliminary study of the species. The material is so fragmentary and poorly preserved that it is difficult to satisfactorily determine the limits of many of the species.

Formation and locality.—Cambrian. Saint John formation, Ratcliff's Millstream, N. B.

PTYCHOPARIA TENER, Hartt.

Plate v, figs. 6, 6a, b.

Conocephalites tener, Hartt, 1868, *Acadian Geology*, Dawson, 2d ed., p. 652.

Conocephalites neglectus, Hartt, 1868, *Acadian Geology*, Dawson, 2d ed., p. 654.

Description.—"Minute, glabella ovate-conical, truncate at base, rounded in front, where it is about half as wide as at occipital furrow, slightly contracted behind, length about equal to width at occipital furrow, strongly depressed convex, more elevated at base than at front, and higher also than fixed cheeks; aspect varies with state of preservation of specimens, arcuate, rounded, convex, or concave; the middle seems to be inclined to project back slightly over the occipital furrow, slopes abruptly to occipital furrow, which is moderately deep, wide, and narrowed, and slightly inclined forward at the ends, where it terminates abruptly; bounding groove deeper than other grooves in head; occipital ring projecting backward bodily beyond higher margin, with the axis of its fold inclined more or less backward, and produced in the middle into a short conical backward inclined spine; anterior limb regularly arched, as if the outlines of the complete head were semicircular.

"Fixed cheeks, anterior border broad, flat concave, rising more or less abruptly to a sharp, thin, marginal fold; width between anterior extremities of cheek sutures equal to or about twice width of glabella at base. Cheek-lobes but slightly convex, and much more depressed than the glabella. Ocular ridges very distinct, thin, sharp, elevated ridges, that begin about inner edge of cheek-lobes, just behind rounded front of glabella, run outward and backward at an angle of 60° to 65° to the antero-posterior diameter. They are at first straight, but soon begin to bend backward more and more abruptly, forming a fragment of a spiral, their extremities being slightly directed inwards. The width between the ocular lobes is about equal to twice the length of the glabella. The ocular ridges are inclined outwards and forwards. Another ridge of the same appearance begins a very short distance behind the origin of the former, and on the very margin of the cheek-lobes, and, diverging from the margin nearly opposite to the base of the glabella, bends off abruptly along the posterior margin of the cheek-lobe, describing a curve, whose convexity is directed backwards. This ridge terminates considerably outside of the ocular lobe, at a point distant from the glabella about equal to half the width of the latter at its base. This ridge is usually found inclined in the opposite direction to the former,

viz, inward and backward. Posterior margin of fixed cheeks moderately and regularly S curved, the inner halves curving forwards, the outer halves backwards, with a marginal fold most elevated in the middle, but much less so than the ridges of the cheek-lobe or the anterior fold. This fold becomes double at about the middle, by the appearance of a groove running along its summit, and it appears to run out before reaching the lateral suture. The width between the posterior extremities of cheek-sutures is considerably greater than between the anterior extremities or between the ocular lobes. Glabella without furrows."

This is a very striking and peculiar species, owing to the development of the sharp ocular ridges and the ridges between them and the glabella.

Associated with *P. tener* is a form described by Mr. Hartt as *O. neglectus*:

Description.—"Glabella regularly semi-elliptical; length, exclusive of occipital ring, about two-thirds of the width at base, moderately convex. Highest at middle of base and sloping with a regular curve toward the front. Traces of two pairs of glabellar furrows on the sides. Occipital furrow deep and concave. Occipital ring with straight parallel margins, narrow, with a short conical spine directed upward."

The type specimen, No. 341, of Mr. Hartt's list, shows the same ocular ridges as in *P. tener* and also the same ridges on the inner side of the palpebral lobes. The specimen has been compressed so as to shorten and widen the glabella, and give it the characters mentioned by Mr. Hartt. On the evidence of the material in the collection, it does not appear to represent a distinct species from *P. tener*.

Formation and locality.—Cambrian. Saint John formation, Portland, a little northward of Saint John, N. B.

FAUNA OF THE BRAINTREE ARGILLITES.

Wishing to examine typical specimens of *Paradoxides Harlani*, the writer visited Boston, and through the kindness of Mr. Alpheus Hyatt, curator in charge of the collections of the Boston Society of Natural History, he not only obtained access to the collection from the Braintree argillites, but the loan of such specimens as were wished for study and illustration. Mr. Alexander Agassiz also gave permission to use material in the collections of the Museum of Comparative Zoölogy, and Mr. N. S. Shaler placed his private collection at the writer's disposal. It is owing to these favorable conditions that I am able to present at this time illustrations and descriptions of the fauna of the Braintree argillites.

The first notice of the presence of fossils in the patches of argillite associated with the Quincy granite in the north end of the town of Braintree, Mass., was by the late Mr. William B. Rogers, who called the attention of the members of the Boston Society of Natural History to it when exhibiting specimens of a large trilobite found at Hayward's quarry (Proc. Boston Soc. Nat. Hist., vol. vi, p. 27, 1856). Subsequently Mr. Rogers traced the history of the trilobite described by Mr. Jacob Green as *Paradoxides Harlani*, in 1834, and showed quite conclusively that it came from Hayward's quarry and was identical with the species found there. Mr. Henry D. Rogers published the best figure of the species yet given, with remarks on its discovery, &c. (Geol. Surv. Penn., vol. ii, p. 816, 1858).

Numerous collectors obtained specimens of *Paradoxides Harlani*, but it is not until 1861 that we find any notice of other species. Mr. Albert Ordway then states that he had found a fragment of a trilobite similar to that described in the *Paradoxides* beds of Newfoundland, in association with *Paradoxides Bennetti*, and which he referred to the genus *Ellipsocephalus*. He also mentions the discovery of "a distinct fucoidal impression which shows three branches, each about 4 inches long, but not sufficiently well marked to afford any evidence with regard to its nature" (Proc. Boston Soc. Nat. Hist., vol. viii, p. 6, 1862). The small trilobite is probably the same as that subsequently described by Mr. R. P. Whitfield as *Arionellus* = *Agraulos quadrangularis* (Bull. Amer. Mus. Nat. Hist., vol. i, p. 147, 1884). Mr. Ordway also published a figure of the head of *Paradoxides Harlani*, when comparing that species with *Paradoxides spinosus*, Boeck, which Mr. Barrande considered as identical with *P. Harlani* (Bull. Geol. Soc. France, vol. xvii, pp. 545-548, 1860).

In the year 1863 a restored figure of *Paradoxides Harlani*, by Mr. F.

B. Meek, was published in Dana's Manual of Geology and repeated in each subsequent edition of the Manual. This very well represents the general characters of the species.

The publication of the second described species by Mr. Whitfield gives a stronger interest to the fauna, which is now increased by the addition of another species of trilobite, *Ptychoparia Rogersi*, and a species of Pteropod, *Hyolithes Shaleri*.

In seeking for a fauna in the Cambrian system of North America to compare with that of the Braintree argillites; we are at once directed to the Paradoxides beds of Newfoundland by the almost perfect identity of the leading type of each locality, *Paradoxides Harlani* and *P. Bennetti*. I think it has yet to be decided that the two are distinct species. *Hyolithes excellens*, Billings (Pal. Foss., vol. ii, pt. 1, p. 70, 1874), is very closely related to *H. Shaleri*, more so than to any other American species, and *Agraulos socialis*, Billings (*loc. cit.*, p. 71), is of the same type as *A. quadrangularis*, Whitfield, as shown by figure 1 of plate vii. *Ptychoparia Rogersi* does not appear to be represented in the Newfoundland Paradoxides beds, unless it be by *Ptychoparia (Solenopleura) communis*, Billings (*loc. cit.*, p. 72).

Mr. Barraude has shown the strong resemblance between *Paradoxides spinosus*, of the Bohemian Basin, and *P. Harlani*; and the Paradoxides beds of Sweden, Bohemia, Wales, Newfoundland, and Braintree have frequently been correlated in a general manner by authors.

Genus HYOLITHES, Eichwald.

HYOLITHES SHALERI, n. sp.

Plate vii, figs. 4 4a-c.

Form an elongate triangular pyramid, slightly arching towards the dorsal side and expanding regularly from the apex towards the aperture. Transverse section midway of the length, semielliptical, with a width twice as great as the height; the lateral angles acute. Ventral face gently convex transversely, curving slightly longitudinally. Dorsal face strongly convex, and showing a slight tendency to become angular at the center, a little concave longitudinally. From the direction of the surface lines the aperture appears to have been oblique. Operculum unknown. Surface marked by lines of growth that on the dorsal side are nearly transverse, and on the ventral side arched forward; traces of fine longitudinal lines are shown in the matrix of the ventral side.

Dimensions.—Length, about 90^{mm}; breadth of aperture, 23^{mm}; height of aperture, about 14^{mm}. The apex is broken away, and the aperture a little crushed by compression.

The most nearly related American species is *Hyolithes excellens*, Billings (Pal. Foss., vol. ii, pt. 1, p. 70, fig. 39, 1874), from Smith's Sound,

Trinity Bay, New Foundland. Mr. Billings's description and figures lead me to think that the two species are closely allied, but still distinct, species.

The specific name is given in honor of the discoverer of the specimen illustrated, Mr. N. S. Shaler, Paleontologist of Harvard University.

Formation and locality.—Lower Cambrian. Braintree argillites, Hayward's Quarry, South Braintree, Mass.

Genus PARADOXIDES, Brongniart.

PARADOXIDES HARLANI, Green.

Plate vii, fig. 3; plate viii, figs. 1, 1a-e; plate ix, fig. 1.

Paradoxides Harlani, Green, 1834, Amer. Journ. Sci., vol. xxv, p. 336.

Rogers, Wm. B., 1856. Proc. Boston Soc. Nat. Hist., vol. vi, pp. 27-29, pp. 40-44; *ibid.*, Stodder, p. 369. Rogers, Wm. B., also in Amer. Jour. Sci., 2d ser., vol. xxii, p. 296. Rogers, H. D., 1858. Geol. Penn., vol. ii, p. 816. fig. 590.

Ordway, 1861. Proc. Boston Soc. Nat. Hist., vol. viii, pp. 1-5; *ibid.*, Jackson, p. 58.

Dana, 1863. Manual of Geology, p. 189, fig. 245. This figure appears in each subsequent edition of the Manual.

Compare *Paradoxides spinosus*, Boeck.

Mr. Green's original description is as follows:

Description.—"The contour of the buckler in this species cannot be satisfactorily determined from our present specimen; the anterior and posterior parts of it are well defined, but the cheeks on each side are either mutilated or obscured. The *front* is very much elevated above the surface of the cheeks. It rises a little before the anterior edge of the buckler, is rounded in front, and gradually tapers towards the middle lobe of the abdomen, with which it forms a regular continuation. On its posterior surface there are three transverse furrows; the upper one crosses it a little obliquely, and there is on each side above a considerable protuberance. The *cheeks* were, no doubt, in the form of spherical triangles, but whether the outer angles terminated in acute prolongations cannot, from our specimen, be determined. The *organs of vision* appear to be entirely wanting. There are two shallow depressions on each side of the cheeks, commencing near the protuberances on the front, and running towards the lateral edges of the buckler. The posterior border of the buckler, where it joins the lobes of the abdomen, is marked by a transverse groove, nearly continuous with the lower transverse furrow on the front; this groove at its commencement appears to bifurcate outwards. The *abdomen* and *tail* cannot be distinguished from each other. There are seventeen distinct articulations in both. The middle lobe is very convex, and is separated from the lateral ones by a deep channel; it gradually tapers to an obtuse tip. In our specimen there is a small part of the tail of another trilobite deposited in this place, which at first sight appears to be a dislocated fragment

of our animal. The *lateral lobes* are flattened; the costal arches are very distinct near their insertion, and for about half their length, but towards their free extremities they are a good deal obliterated. There appears to have been a delicate *membranaceous prolongation* for a considerable distance beyond the solid portion of each rib. This organization is very apparent on the costal arches of the tail. There is a deep groove running obliquely over the upper surface of each rib. *Length* of the fossil about 9 inches; *breadth*, about 4 inches."

Mr. Green did not know the true locality of the specimen sent to him by Mr. Harlan, and it was not until twenty-two years after that Mr. W. B. Rogers announced the discovery of specimens of the same species at South Braintree, near Boston, Mass., identifying the locality of the specimen used by Mr. Green in his original description. The description is unaccompanied by figures, but fortunately Mr. Green made numerous casts of the type, one of which is now before me. It is the narrow form of the species, measuring 22^{cm} in length by about 14^{cm} in width across the back of the head, and 12^{cm} across the widest portion of the thorax. The palpebral lobes and movable cheeks are broken away, also the posterior segment of the thorax and the pygidium is displaced. Mr. Green describes the species as having 17 thoracic segments; but in a very fine specimen now in the collection of the Boston Society of Natural History, 18 segments are shown between the head and pygidium; and Mr. Henry D. Rogers gives a very perfect figure with 18 thoracic segments.

Mr. Ordway, in making a comparison between that species and the Bohemian *P. spinosus* (Proc. Boston Soc. Nat. Hist., vol. viii, p. 3), gives an outline figure of the head of *P. Harlani*, which is evidently a restored figure made up from fragments.

At the request of Mr. J. D. Dana, Mr. F. B. Meek drew a figure of *P. Harlani* for the Manual of Geology, from more or less fragmentary specimens in Mr. Dana's collection. This is one of the best, but not the best (see Rogers's figure), representations of the species yet published; but in the presence of 19 segments in the thorax, and the short extension of the posterior pleuræ and other details, it varies from specimens before us. There is considerable variation in the species in the relative length and breadth of individuals. In a form similar to the type, the length is 21^{cm}, and the greatest breadth of the thorax 10^{cm}. In two broad specimens the length is 25^{cm} and 35^{cm}; the breadth of the thorax 16^{cm} and 20^{cm}., respectively. This variation is also shown in the pygidium, as may be seen by comparing figs. 16, *c*, *d* of plate viii. In the head the greatest variation is seen in the contour of the frontal margin and the gradual development of the frontal limb and rim. On the small specimens the frontal limb is very short and more or less rounded. With the increase in size, the space between the glabella and the marginal rim increases in width, and the latter broadens and flattens out. Our information respecting the postero-lateral spines of the head is limited. On the narrow form, fig. 1, plate ix, they extend back to a point opposite the

fourteenth thoracic segment; and the movable cheek, fig. 3, plate vii, shows a long, well-developed spine. There is a limited range of variation in the extension of the pleuræ of the thoracic segments, but the material for study is too limited to say what value may be placed upon it. In reviewing all the variations, I do not think that more than one species is indicated. A narrow and broad variety might be designated if thought desirable.

Of American species of the genus *Paradoxides*, *P. Bennettii*, Salter (Quart. Journ. Geol. Soc., vol. xv, p. 552, fig. 1, 1859), from Newfoundland, is the most nearly related. The figure accompanying Mr. Salter's description appears to have been taken from a distorted specimen, as the two specimens now before me, although imperfect, show a form very similar to that of *P. Harlani*.

Mr. Ordway has described the differences between *P. Harlani*, Green, and *P. spinosus*, Boeck (Proc. Boston Soc. Nat. Hist., vol. viii, pp. 1-5, 1861), and from my own observations and comparisons I cannot but agree with Mr. Ordway that the two species are represented. Mr. Barrande considered *P. spinosus* and *P. Harlani* as one species (Bull. Geol. Soc. France, vol. xvii, pp. 545-547, 1860). Mr. Barrande had the cast of the imperfect specimen described by Mr. Green to compare with specimens of *P. spinosus*, and photographs of three specimens sent to him by Mr. W. B. Rogers. The two species are, however, very closely related.

Formation and locality.—Lower Cambrian. Braintree argillites. Hayward's quarry, South Braintree, Mass.

Genus PTYCHOPARIA, Corda.

PTYCHOPARIA ROGERSI, n. sp.

Plate vii, fig. 2.

This species is known only by the central portions of the head, and two specimens showing portions of the thorax.

Glabella cylindro-conical, rounding rather abruptly in front, posterior pair of glabellar furrows very faintly shown in one specimen; dorsal furrow strongly defined; occipital furrow rounded, well marked and extending out across the fixed cheeks; occipital ring rather narrow, rising at the center and extending backwards in a short, strong spine; fixed cheeks of medium width, moderately convex, and sloping forward to unite with the frontal limb; ocular ridges shown only on one specimen; starting a little back of the anterior end of the glabella, they extend obliquely backward to the small palpebral lobe; frontal limb rather narrow; it curves downward for a short distance in front of the glabella and then up to the frontal rim. The facial sutures cut the anterior margin so as to leave a narrow frontal limb, and then extend obliquely outward and backward to the palpebral lobe; back of this they extend obliquely outward to the posterior margin of the head.

Thorax formed of well marked, strongly trilobed, narrow segments; the axial lobe about one-third of the entire width anteriorly, and tapering rather rapidly backward; pleural grooves very narrow. Number of segments in the thorax unknown.

The condition of the preservation of the surface renders its character uncertain. It is apparently roughened or granulose.

Owing to the lateral compression of the specimen illustrated, the form of the glabella is too elongate. In hopes of getting better specimens the further illustration of the species is deferred.

The specific name is given in honor of Mr. W. B. Rogers, the distinguished geologist, who took so strong an interest in the discovery of the Braintree paradoxides beds in 1856.

Formation and locality.—Lower Cambrian. Braintree argillites. Hayward's quarry, South Braintree, Mass.

Genus AGRAULOS, Corda.

AGRAULOS QUADRANGULARIS, Whitfield.

Plate vii, fig. 1.

Arionellus quadrangularis, Whitfield, 1884. Bull. Amer. Nat. Hist., p. 147, plate xiv, fig. 8.

Description.—"Known only by the glabella and fixed cheeks, which are of small size, and as united are subquadrangular in form and depressed convex. Glabella quadrangular a little narrower in front than at the occipital line, squarely truncate in front and destitute of any appearance of glabellar furrows. Dorsal furrows bounding the glabella, deeply marked. Fixed cheeks about half as wide as the glabella, moderately convex in the middle. Frontal limb about as wide as the fixed cheeks, convex on the surface and strongly arched on the front border; no marginal rim exists. Palpebral lobes, one of which is visible, minute, and but slightly raised above the general surface of the fixed cheek adjacent. Occipital ring narrow. General surface smooth. This species is so entirely distinct in its quadrangular glabella that there is no possibility of confounding it with any other American species of the genus."

We have two specimens of this species showing the central portions of the head and fixed cheeks. The glabella is more elongate and less quadrangular than in the type specimen which appears to be longitudinally compressed, and also without the occipital ring and the posterolateral portions of the fixed cheeks. Restoring these parts in outline on the figure given by Mr. Whitfield, leads to the conclusion that we have but one species represented by specimens, varying considerably owing to their condition of preservation. The largest head is from the collection of Mr. N. S. Shaler, and measures 18^{mm} in length. A smaller head in the collection of the Boston Society of Natural History is 9^{mm} in length, and shows a small spine on the center of the occipital ring.

The first notice of this species is by Mr. Albert Ordway (Proc. Boston Soc. Nat. Hist., vol. viii, p. 6, 1861), where he refers it to the genus *Ellipsocephalus*, but does not propose a specific name. Mr. J. Marcou had a specimen in his collection for many years, but it does not appear to have been noticed until studied by Mr. Whitfield.

Formation and locality.—Lower Cambrian. Braintree argillites, associated with *Paradoxides Harlani* at Hayward's quarry, South Braintree, Mass.

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Bull. 10—4

ON A NEW GENUS AND SPECIES OF PHYLLOPODA FROM THE MIDDLE CAMBRIAN.

Genus PROTOCARIS, n. gen.

Carapace without evidence of a dorsal suture, rounded on the dorsal line, and bent downward on the sides; without any rostrum. Body many-jointed—31 segments extending out from beneath the carapace; the last segment broader than the preceding, and terminating in two spines. Type *Protocaris Marshi*.

In comparing *Protocaris* (*P. Marshi*) with *Hymenocaris* (*H. vermicauda*) (Salter, 1852. Rep. Brit. Assoc., pt. 2, Notices and Abstracts, p. 58; Mem. Geol. Surv. Gt. Brit., vol. iii, p. 293, plate ii, figs. 1-4; plate v., fig. 25, 1866) we find that in the simple, bent or folded eyeless shield or carapace they are closely related, but in the structure of the body they differ materially. *Hymenocaris* has, in one instance, 9 strong segments shown in its more elongate body, the terminal one ending in three pairs of spines; usually 6 or 7 segments are seen, 8 or 9 are less frequent (Brit. Assoc. Rep. 1883, p. 219). *Protocaris* has 30 narrow segments, a large terminal segment or telson with two rather strong caudal or terminal spines.

PROTOCARIS MARSHI, n. sp.

Plate x, fig. 1.

The specimen on which the genus and species is founded is compressed between the laminae of the slate so that the entire outline of the carapace is shown and the body is widened out. As flattened the carapace is rounded, quadrangular in outline, with a more or less distinctly defined marginal rim all around. The general surface appears to have been smooth. No evidence of eyes.

The body projecting beyond the carapace is about two-thirds as long as the carapace, narrows posteriorly, and is made up of numerous narrow segments, each about one-third of a millimeter in breadth; the last segment or telson, which is 2.5^{mm} long, supports two caudal spines 7 or 8^{mm} in length; 30 segments appear between the posterior edge of the carapace and the telson; the segments appear to have been smooth and without a spinose or crenulated posterior margin; the telson and caudal spines also appear to have been smooth and without ornamentation.

Dimensions.—Total length, 42^{mm}; length of carapace, 21^{mm}; width, 26^{mm}; length of body, 15^{mm}, exclusive of caudal spines; width of body, where it passes beneath the carapace, 10^{mm}; at telson, 4^{mm}.

The specific name is given in honor of Prof. O. C. Marsh.

Formation and locality.—Middle Cambrian. Georgian formation. Parker's farm, town of Georgia, Vt.

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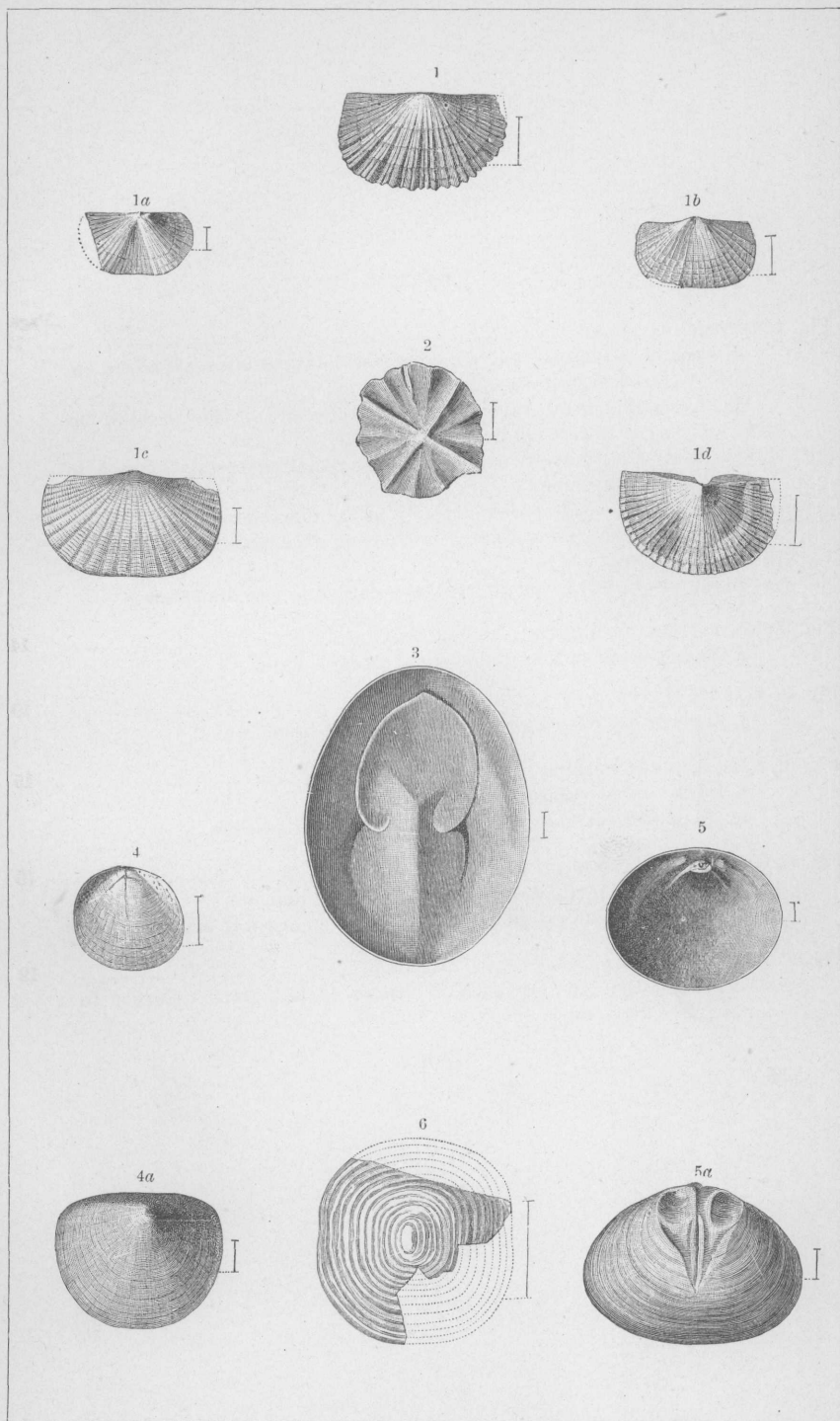
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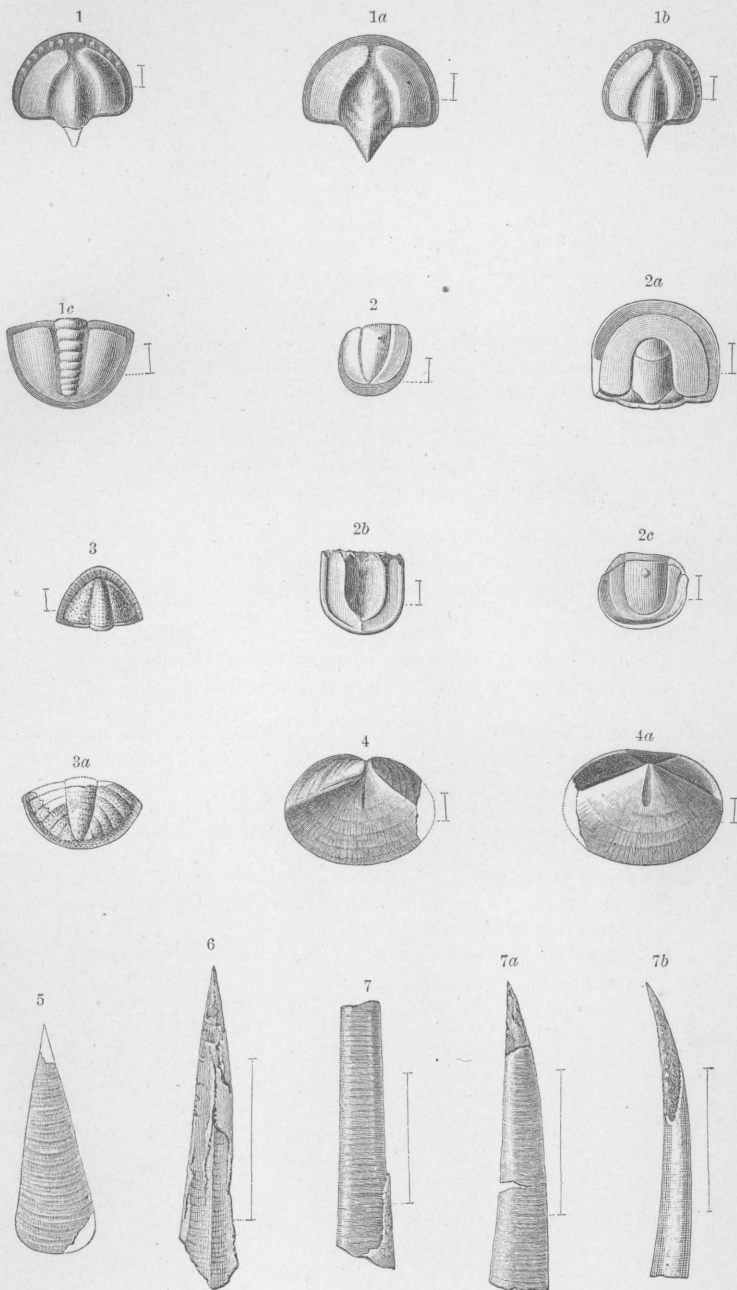
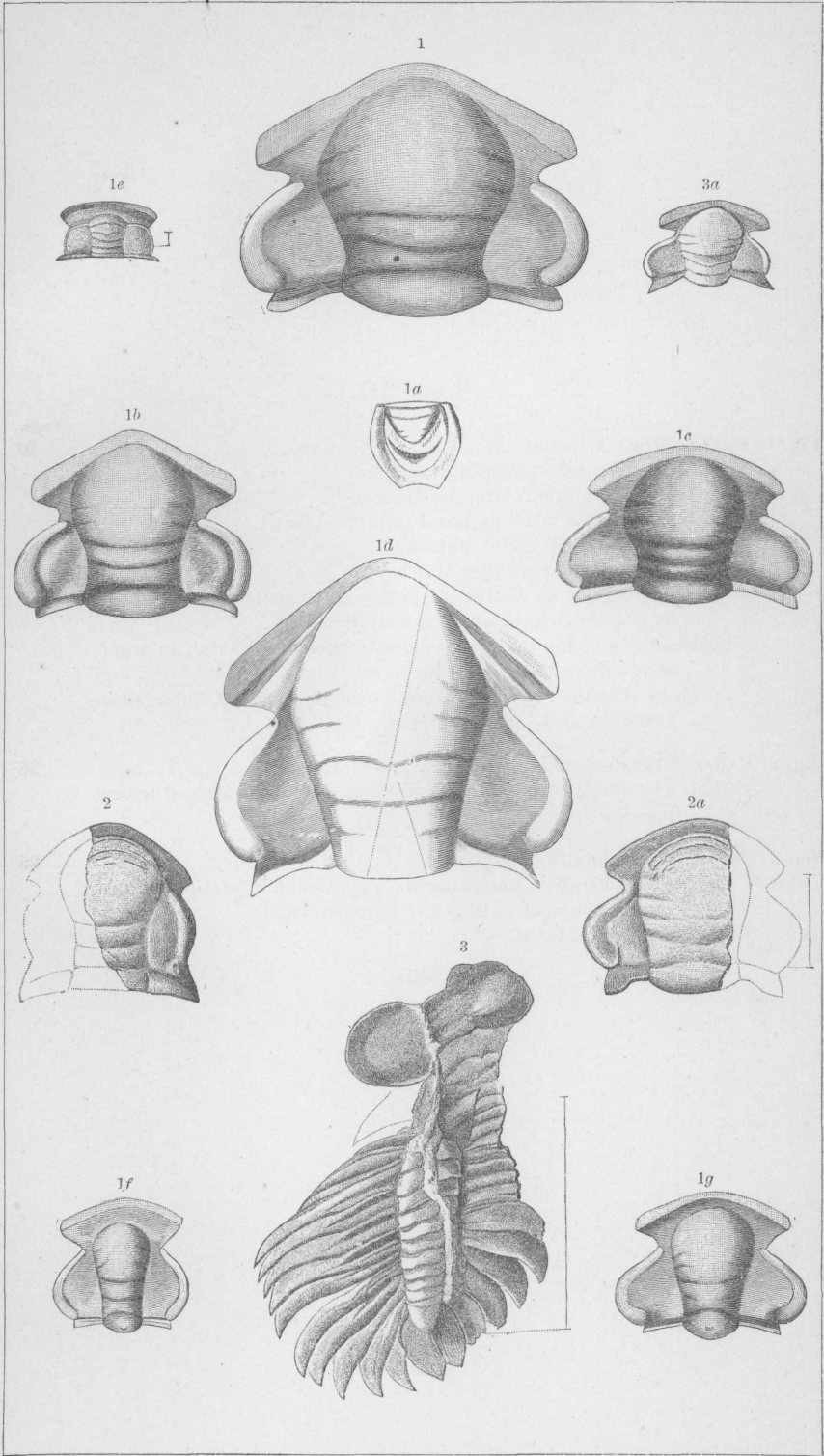


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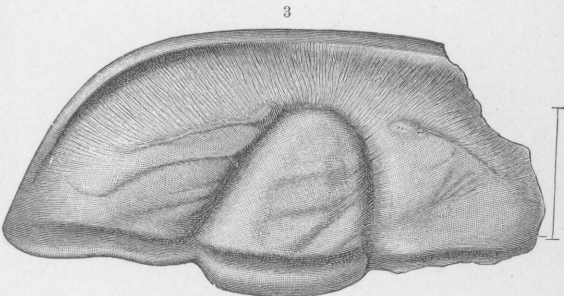
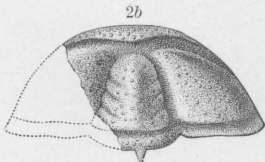
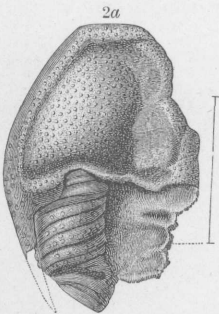
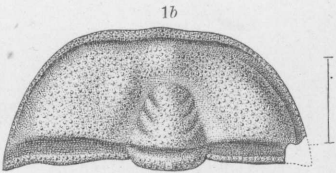
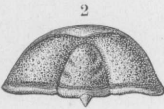
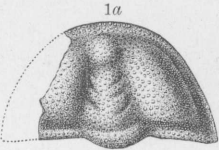
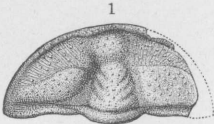


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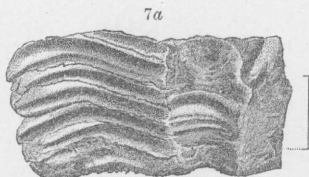
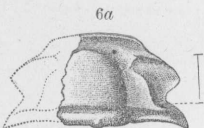
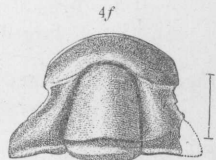
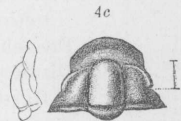


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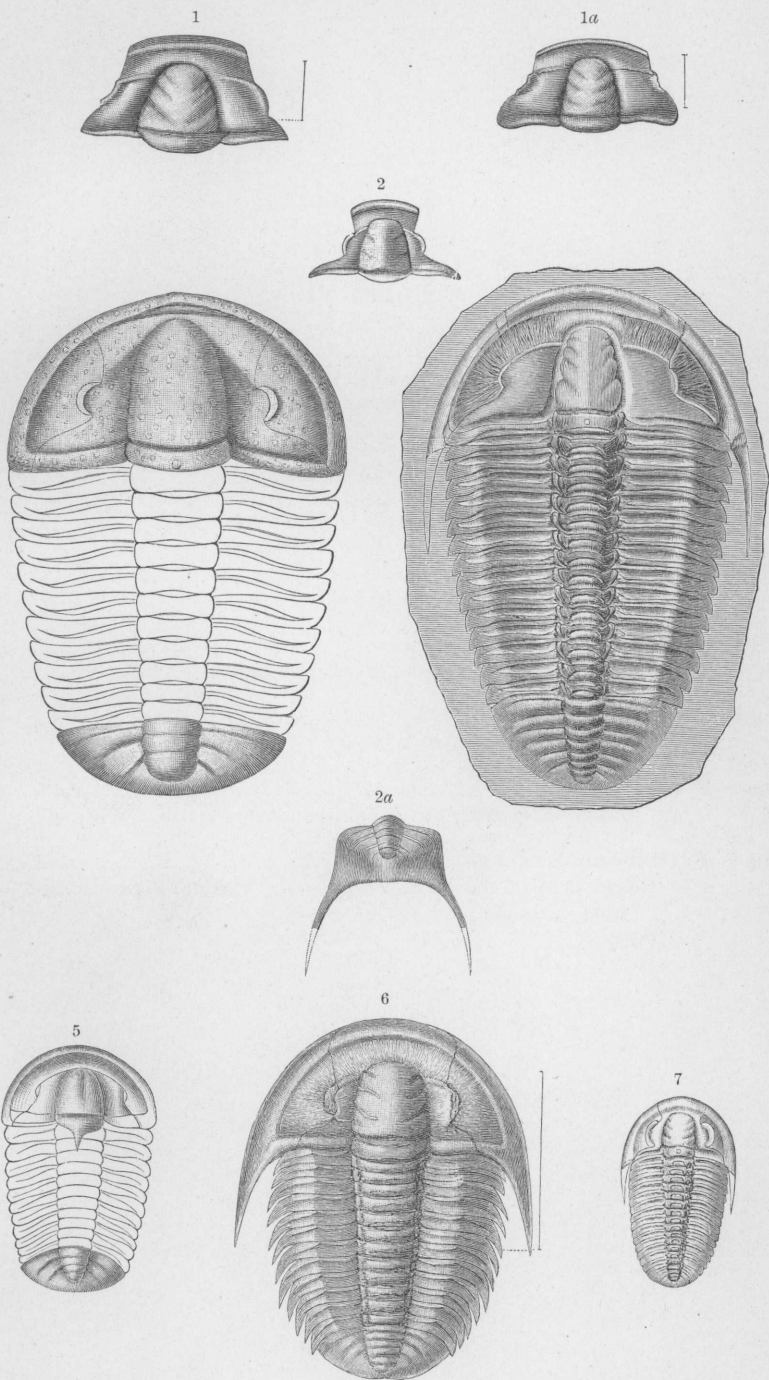


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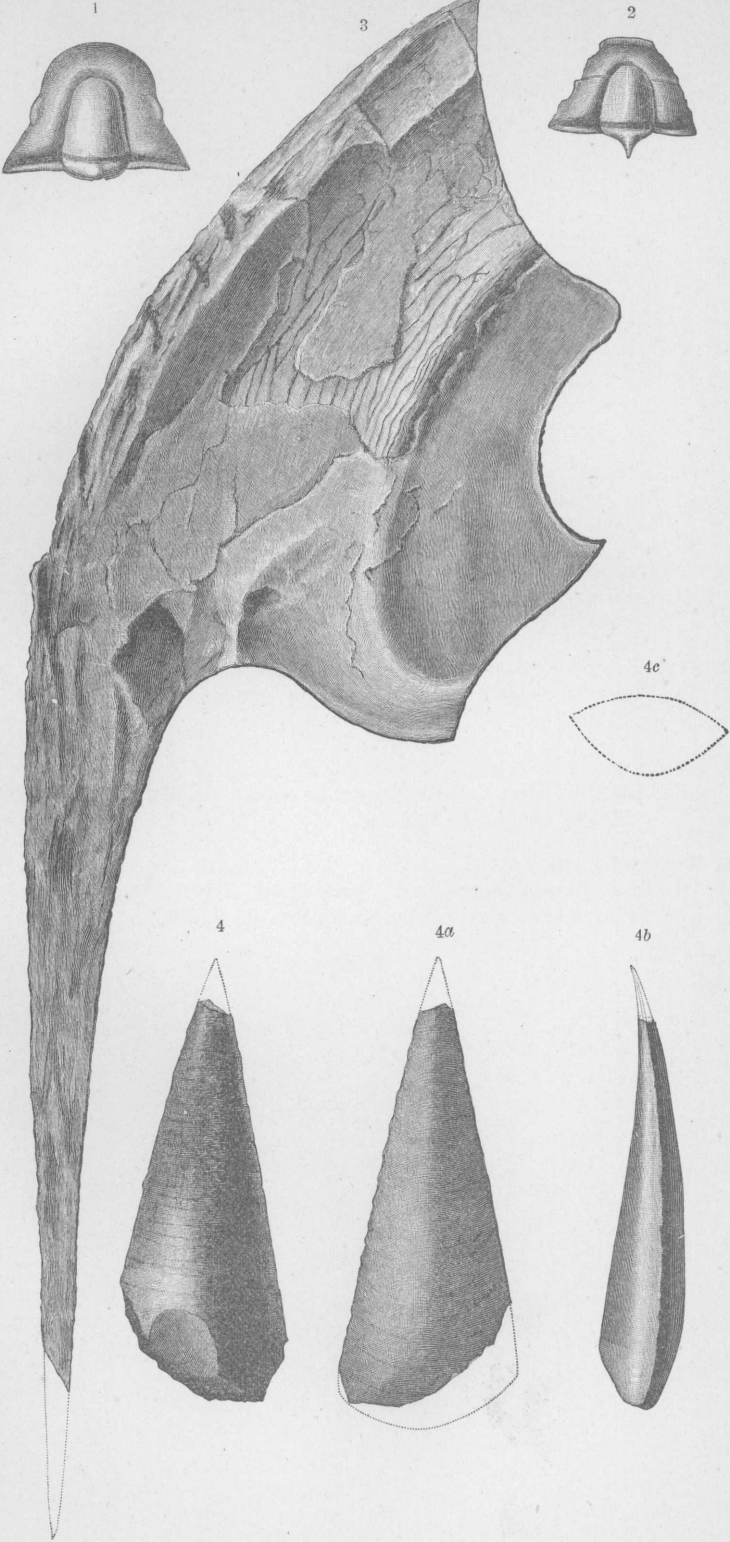


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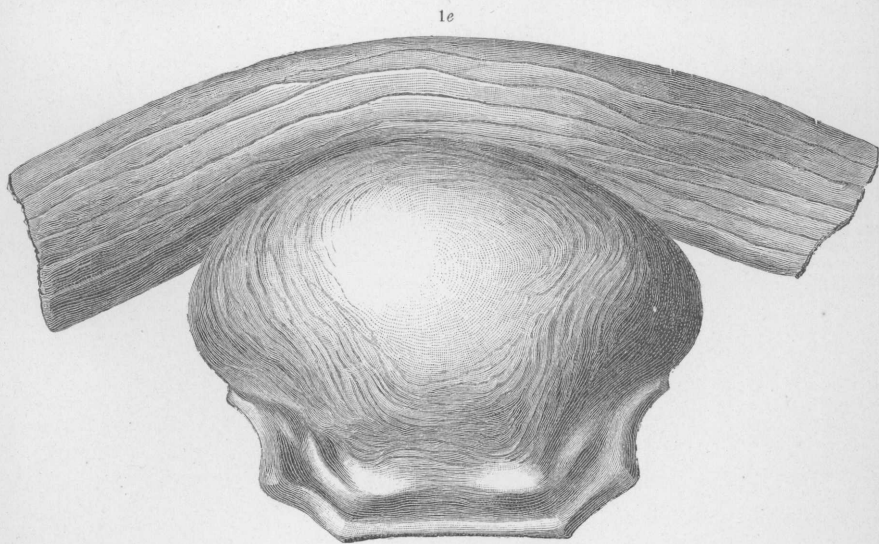
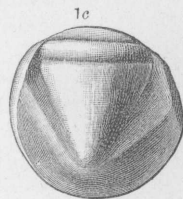
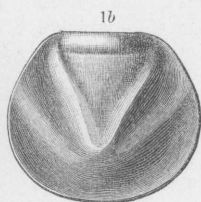
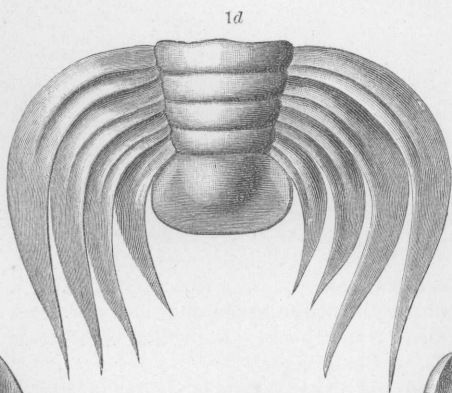
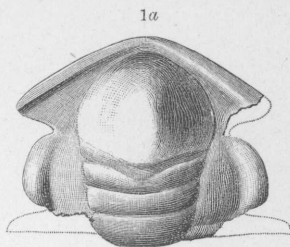
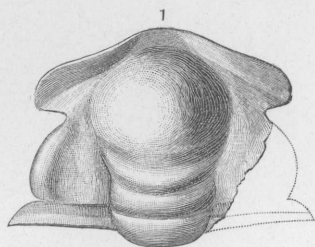
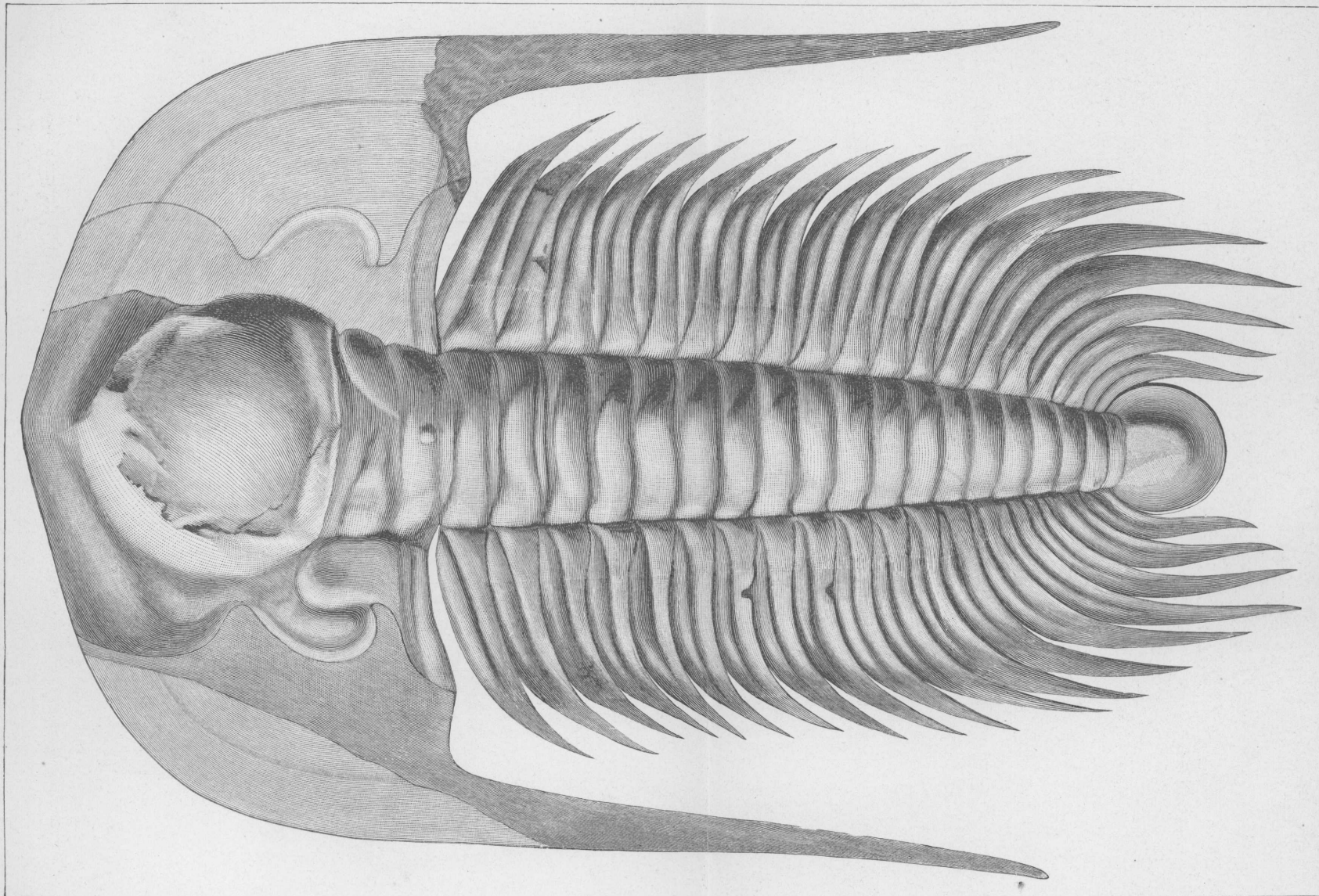


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PECILOPODA.

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Fig. 1. PROTOCARIS MARSHI

1. View of the type specimen as it occurs flattened out on the shale.
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