An Appraisal of the Great Basin Middle Cambrian Trilobites Described Before 1900

By ALLISON R. PALMER

A SHORTER CONTRIBUTION TO GENERAL GEOLOGY

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Of the 29 species described prior to 1900, 27 are redescribed and 29 refigured, and a new name is proposed for 1 species

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By ALLISON R. PALMER

ABSTRACT

All 29 species of Middle Cambrian trilobites that were described from the Great Basin of Western United States prior to 1900 are refigured and 27 redescribed. Complete information is presented concerning the stratigraphic occurrences of the species in terms of present knowledge of the Cambrian stratigraphy of the Great Basin, the original and present taxonomic designations of the species, and the localities from which the species were obtained. A new name, *Modocia nevadensis*, is proposed to replace *Modocia oweni* (Walcott) not *Modocia oweni* (Meek and Hayden).

INTRODUCTION

This paper has been prepared as a reference for paleontologists and stratigraphers dealing with the Middle Cambrian rocks and their included fossils in the Great Basin of Western United States.

Cambrian trilobites from the Great Basin were first collected by field parties of the U. S. Geographical and Geological Surveys West of the 100th meridian and the U. S. Geological Exploration of the 40th Parallel in the late 1860's and early 1870's. A total of 11 species of Middle Cambrian age were described by Meek (1870, 1873), White (1874, 1877), and Hall and Whitfield (1877) from Survey collections from the House, Oquirrh, and Wasatch Ranges of Utah (fig. 3). The only other published records before 1900 of Middle Cambrian trilobites from the Great Basin are by Walcott (1884, 1886) who collected and described a total of 18 species mostly from the Eureka and Pioche mining districts and the Highland Range in Nevada.

Although many of these Great Basin species described in the early reports have been discussed, illustrated, or mentioned since 1900 and some additional material has been described, no comprehensive reexamination of the trilobites from the early collections has ever been presented. The original engraved illustrations and most of the subsequent photographic illustrations of the species are inadequate according to present paleontologic standards. Furthermore, references to the species and changes in their generic assignments are scattered through many publications by both American and foreign paleontologists. An understanding of those species is a necessary prerequisite to any study of Middle Cambrian trilobites from the Great Basin. However, in most instances, such an understanding cannot be gained by reading published descriptions and examining published illustrations of the species.

All of the species reported from Middle Cambrian rocks of the Great Basin before 1900 are either described or discussed, or both, in this publication. Unless otherwise stated, the specimens figured in the original illustrations are shown on plates 13–17 by stereophotographs. The history of each species name is given in the synonymy or discussion of the species. Original descriptions are quoted where there is little or no new descriptive information. The original and the present generic assignments of the species are listed on page 57; the stratigraphic and geographic occurrences of the type specimens of each species are listed on pages 57 and 58; and detailed locality information is given on page 58. Unless otherwise stated only the formation and locality from which the type or figured material came is listed.

The assignments of trilobites to particular formations in the Eureka district result from the study of material collected by the writer or Josiah Bridge since the formational sequence was redescribed by Wheeler and Lemmon (1939). The sequence was first described, in what is now considered to be correct stratigraphic order, by Hague (1883), and most of the present formational names were proposed by him or by Walcott (1908). Resser believed that the Dunderberg shale and Secret Canyon shale were partial equivalents. In accordance with this interpretation, Resser assigned (1935, 1936, 1937, and *in* Walcott, 1924, 1925) the Dunderberg faunas to the Secret Canyon shale and the Secret Canyon faunas to the Eldorado limestone.

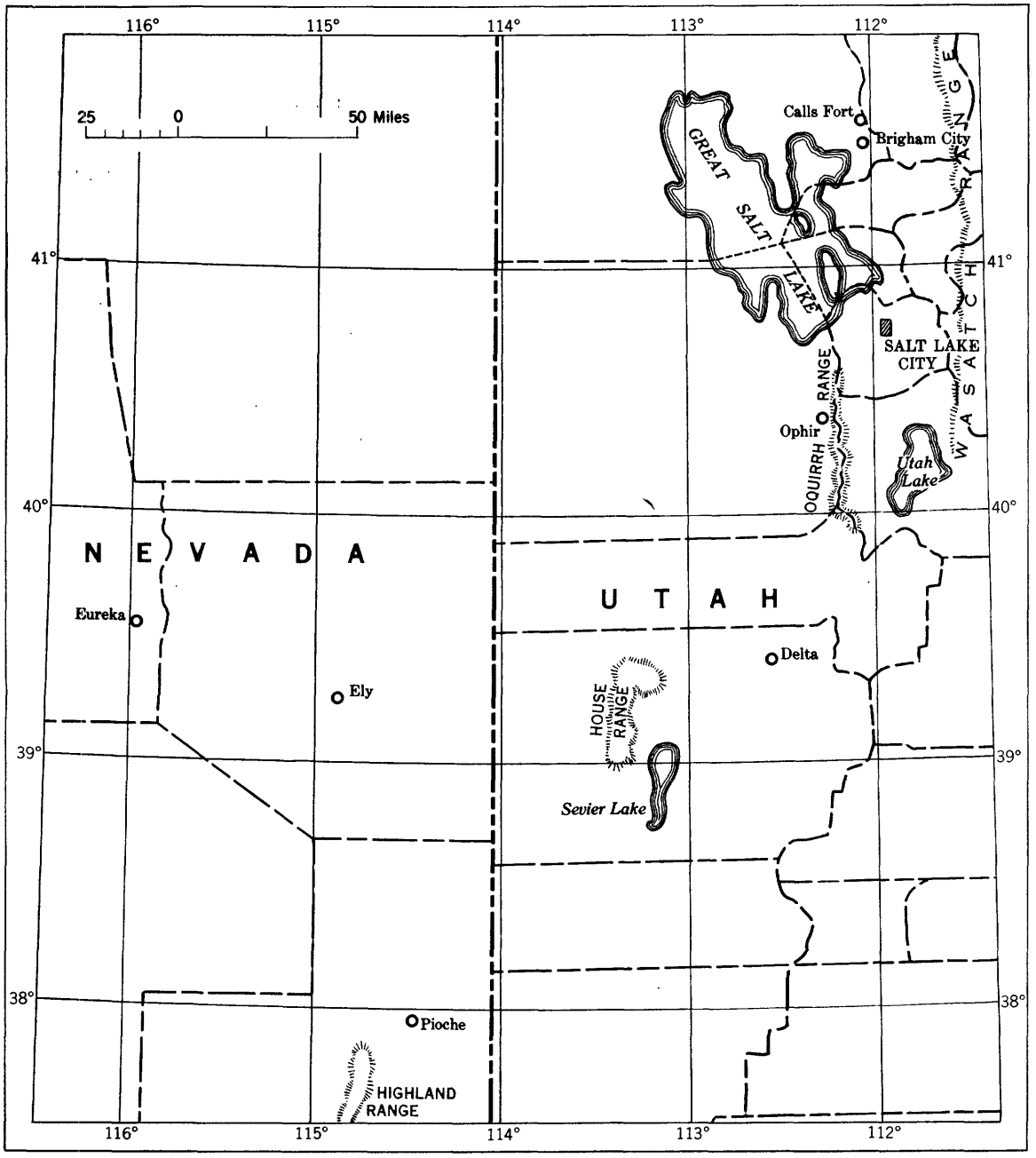

FIGURE 3.—Map showing areas in the Great Basin from which Middle Cambrian trilobites described before 1900 were obtained.

Wheeler and Lemmon (1939) reassigned most of the described trilobites from the Eureka district to the formations from which they were originally collected. However, their Geddes limestone and the Hamburg limestone, which they state to be sparingly fossiliferous and to lack diagnostic fossils, contain distinctive faunas assignable to the *Bathyuriscus-Elrathina* zone (Rasetti, 1951) and an unnamed latest Middle Cambrian zone respectively.

Stratigraphic assignments for the fossils from areas outside of the Eureka District are based principally on the work of Deiss (1938).

ORIGINAL AND PRESENT TAXONOMIC NAMES OF SPECIES

The taxonomic designation used in this paper for each of the 29 species described from the Middle Cambrian rocks of the Great Basin prior to 1900 is given below.

Original name	*Present name*
Agnostus interstrictus White	*Peronopsis interstrictus* (White).
Agnostus richmondensis Walcott	*Ptychagnostus richmondensis* (Walcott).
Agnostus seclusus Walcott	*Kormagnostus seclusus* (Walcott).
Asaphiscus wheeleri Meek	*Asaphiscus wheeleri* Meek.
Bathyuriscus howelli Walcott	*Athabaskia howelli* (Walcott).
Conocephalites subcoronatus Hall and Whitfield	*Alokistocare subcoronatum* (Hall and Whitfield).
Conocoryphe (*Conocephalites*) *kingii* Meek	*Elrathia kingii* (Meek).
Crepicephalus? (*Loganellus*) *quadrans* Hall and Whitfied	*Ehmaniella quadrans* (Hall and Whitfield).
Crepicephalus augusta Walcott	*Kochaspis augusta* (Walcott).
Crepicephalus liliana Walcott	*Kochaspis liliana* (Walcott).
Dicellocephalus expansus Walcott	*Olenoides expansus* (Walcott).
Dicellocephalus? quadriceps Walcott	*Kootenia eurekensis* (Resser).
Dikellocephalus? gothicus Hall and Whitfield	*Kootenia quadriceps* (Hall and Whitfield).
Dikellocephalus quadriceps Hall and Whitfield	*Kootenia quadriceps* (Hall and Whitfield).
Dikellocephalus wahsatchensis Hall and Whitfield	*Olenoides wahsatchensis* (Hall and Whitfield).
Ogygia parabola Hall and Whitfield	*Glossopleura producta* (Hall and Whitfield).
Ogygia problematica Walcott	*Holteria problematica* (Walcott).
Ogygia producta Hall and Whitfield	*Glossopleura producta* (Hall and Whitfield).
Ogygia? spinosa Walcott	*Zacanthoides spinosus* (Walcott).
Olenoides typicalis Walcott	*Zacanthoides typicalis* (Walcott).
Oryctocephalus primus Walcott	*Oryctocephalus primus* Walcott.
Paradoxides nevadensis Meek	*Olenoides nevadensis* (Meek).
Ptychoparia housensis Walcott	*Bolaspidella housensis* (Walcott).
Ptychoparia laeviceps Walcott	*Asaphiscus laeviceps* (Walcott).
Ptychoparia? linnarssoni Walcott	*Eldoradia linnarssoni* (Walcott).
Ptychoparia occidentalis Walcott	*Elrathia occidentalis* (Walcott).
Ptychoparia oweni Walcott	*Modocia nevadensis* Palmer, n. sp.
Ptychoparia piochensis Walcott	*Alokistocare piochensis* (Walcott).
Ptychoparia? prospectensis Walcott	*Eldoradia prospectensis* (Walcott).

STRATIGRAPHIC DISTRIBUTION OF SPECIES

In the following table is given the stratigraphic distribution of 26 species of Middle Cambrian trilobites described from the Great Basin prior to 1900.

Stratigraphic distribution of trilobites

Locality	Formation	Fauna
Wasatch Range, Utah	Ute limestone	*Alokistocare subcoronatum* (Hall and Whitfield). *Kootenia quadriceps* (Hall and Whitfield).
	Spence shale member of the Ute limestone.	*Ehmaniella quadrans* (Hall and Whitfield). *Olenoides wahsatchensis* (Hall and Whitfield).
Oquirrh Range, Utah	Ophir shale (?)	*Glossopleura producta* (Hall and Whitfield).
House Range, Utah	Wheeler formation	*Asaphiscus wheeleri* Meek. *Bolaspidella housensis* (Walcott). *Elrathia kingii* (Meek). *Olenoides nevadensis* (Meek). *Peronopsis interstrictus* (White).
Pioche district, Nev	Chisholm shale	*Alokistocare piochensis* (Walcott). *Athabaskia howelli* (Walcott). *Zacanthoides typicalis* (Walcott).
	Pioche shale	*Kochaspis augusta* (Walcott). *Kochaspis liliana* (Walcott). *Oryctocephalus primus* (Walcott).

Stratigraphic distribution of trilobites—Continued

Locality	Formation	Fauna
Eureka district, Nev.	Hamburg limestone (Lower)	*Asaphiscus laeviceps* (Walcott). *Holteria problematica* (Walcott). *Kormagnostus seclusus* (Walcott). *Modocia nevadensis* Palmer, n. sp.
	Secret Canyon shale	*Eldoradia linnarssoni* (Walcott). *Eldoradia prospectensis* (Walcott).
	Geddes limestone of Wheeler and Lemmon (1939).	*Elrathia occidentalis* (Walcott). *Olenoides expansus* (Walcott). *Ptychagnostus richmondensis* (Walcott). *Zacanthoides spinosus* (Walcott).

COLLECTION LOCALITIES

The following list gives complete data for those localities referred to by number in the plate descriptions. Numbers in Systematic descriptions followed by (OS) refer to old series numbers that were assigned to collections under a numbering system established by Walcott and used by Walcott, Resser, Ulrich and others until 1940. Numbers followed by (CO) refer to Cambrian and Ordovician collections numbered under a system established by Josiah Bridge and used since 1940.

The present formational assignment and, wherever known, the name or names of the original collectors are presented for each locality.

U. S. Geological Survey Collections

Locality No.	Stratigraphic assignment, collector, year of collection, trilobites collected
3c (OS)	Shales about 75 feet above the quartzitic sandstones of the Cambrian at Ophir, Oquirrh Range, Tooele County, Utah (Ophir formation?). Collector not known. *Glossopleura producta* (Hall and Whitfield).
20x (OS)	In Wasatch Range near top of gulch, about 2 miles north of Brigham City, Utah (Spence shale member of the Ute limestone). C. E. Resser, Asa A. L. Mathew, E. R. Pohl, Sept. 12, 1926. *Ehmaniella quadrans* (Hall and Whitfield).
30 (OS)	Limestone 8 miles north of Bennetts Spring, on the west slope of the Highland Range, Lincoln County, Nev. (Pioche shale). C. D. Walcott, 1885. *Kochaspis liliana* (Walcott). *Kochaspis nevadensis* Resser.
31 (OS)	Shales at the Chisholm Mine, southwest slope of Ely Mountains, 3 miles northwest of Pioche, Lincoln County, Nev. (Chisolm shale). C. D. Walcott, 1885. *Alokistocare piochensis* (Walcott). *Athabaskia howelli* (Walcott). *Zacanthoides typicalis* (Walcott).
31a (OS)	Limestone and interbedded siliceous shales of the Pioche formation just above the quartzite on the east side of the anticline near Pioche, Lincoln County, Nev. (Pioche shale). C. D. Walcott, 1885. *Kochaspis augusta* (Walcott). *Kochaspis liliana* (Walcott). *Oryctocephalus primus* Walcott.
52a (OS)	500 to 600 feet down northeast slope of Prospect Mountain, Eureka district, Eureka County, Nev. (Secret Canyon shale). C. D. Walcott, 1880. *Eldoradia prospectensis* (Walcott).
55a (OS)	Just beneath Secret Canyon shale on east side of Prospect Mountain, Eureka district, Eureka County, Nev. (Geddes limestone of Wheeler and Lemmon). C. D. Walcott, 1880. *Elrathia occidentalis* (Walcott).
55b (OS)	Black limestone on west side of Secret Canyon, Eureka district, Eureka County, Nev. (Geddes limestone of Wheeler and Lemmon). C. D. Walcott, 1880. *Kootenia eurekensis Resser.* *Olenoides expansus* (Walcott).
58 (OS)	Shaly limestones on east side of New York and Secret Canyons, Eureka district, Eureka County, Nev. (Hamburg limestone). C. D. Walcott, 1880. *Asaphiscus laeviceps* (Walcott). *Holteria problematica* (Walcott). *Kormagnostus seclusus* (Walcott). *Modocia nevadensis* Palmer, n. sp. *Eldoradia linnarssoni* (Walcott).[1]
329 (OS)	Green shales in a canyon about 7 miles north of Brigham, near the village of "Calls Fort," Boxelder County, Utah. (Spence shale member of the Ute limestone). Collector not known. *Ehmaniella quadrans* (Hall and Whitfield). *Olenoides wahsatchensis* (Hall and Whitfield).
329e (OS)	Shales in East Canyon above Ophir, Oquirrh Range, Tooele County, Utah (Ophir formation?). Collector not known. *Glossopleura producta* (Hall and Whitfield).
806 (CO)	Basal Hamburg limestone. Crest of Hamburg Ridge, about 15 feet south of propsect pit, 2,350 feet N. 10° E. of the Eureka tunnel, elevation 8,005 feet, Eureka district, Eureka County, Nev. J. Bridge, Aug. 30, 1939. *Kormagnostus seclusus* (Walcott).
900 (CO)	Piece of "Blue flaggy" (Geddes of Wheeler and Lemmon) float at road junction 1,400 feet W. of N. from pass at head of Secret Canyon (Between Secret and Windfall canyons), Eureka district, Eureka County, Nev. J. Shelton, July 18, 1940. *Zacanthoides spinosus* (Walcott).
901 (CO)	Outcrop of "Blue flaggy" (Geddes of Wheeler and Lemmon) limestone in beds about 1 inch thick on nose of small ridge 2,250 feet S. 41° 30′ W. from BM 8077 on pass between Windfall and New York Canyons. Eureka district, Eureka, Nev. J. Shelton, July 29, 1940. *Ptychagnostus richmondensis* (Walcott).
965 (CO)	Geddes limestone (of Wheeler and Lemmon) on side of Prospect Mountain, 20 feet below large outcrop of gray limestone in middle of slope at west end of Windfall Canyon. Eureka district, Eureka, Nev. A. R. Palmer, Aug. 1951. *Ptychagnostus richmondensis* (Walcott).

[1] This species is from a horizon different than that of the other four listed.

SYSTEMATIC DESCRIPTIONS

The descriptive terminology used here is the same as that used by the writer (Palmer, in press) in an earlier publication. Measurements of figured specimens are given to the nearest one-half millimeter. All of the illustrations on the plates are stereophotographs.

Family AGNOSTIDAE McCoy, 1849

The writer has followed the suprageneric classification of Westergard (1946) wherever possible within this family.

Subfamily PERONOPSINAE Westergard, 1936

Genus KORMAGNOSTUS Resser, 1938

Kormagnostus Resser, 1938, Geol. Soc. America Special Paper 15, p. 49.
Lochman, 1940, Jour. Paleontology, v. 14, no. 1, p. 24.
Shimer and Shrock, 1944, Index Fossils of North America, p. 600.
Palmer, 1954, in press, Jour. Paleontology.

Genotype.—*Kormagnostus simplex* Resser, 1938 (1938a, p. 49).

Diagnosis.—Cephalon with anterior lobe of glabella completely or nearly completely effaced; basal glabellar lobes present. Pygidium with broad, elongate, well-defined axial lobe that is bluntly rounded posteriorly and extends to or nearly to the marginal furrow. Posterolateral marginal spines usually present.

Discussion.—This genus may have been derived from *Hypagnostus*. The principal distinguishing difference is in the pygidium. Most pygidia of species of *Hypagnostus*, as illustrated by Westergard (1946, pls. 4–6) lack marginal pygidial spines and have a posteriorly pointed and sometimes longitudinally shortened axial lobe. These differences are important from a stratigraphic viewpoint because *Hypagnostus* is known only from rocks of Middle Cambrian age, and *Kormagnostus* is almost exclusively Late Cambrian in age. The only species of *Hypagnostus* that has marginal spines on the pygidium comes from the *Lejopyge laevigata* zone at the top of the Middle Cambrian in Sweden.

Kormagnostus seclusus (Walcott)

Plate 13, figures 1–3

Agnostus seclusus Walcott, 1884, U. S. Geol. Survey Mon. 8, p. 25, pl. 9, fig. 14

Description.—Cephalon slightly wider than long, somewhat expanded forward, strongly rounded at the anterolateral corners, gently rounded across the front, and moderately arched transversely and longitudinally. Glabella about one-half the length and one-third the width of the cephalon; tapered slightly forward and squarely truncate anteriorly. Anterior lobe of the glabella not visible on the type specimen but suggested, on a specimen recently collected, by a low, undefined swelling. Posterior lobe highest near the posterior margin; a pair of short furrows notch the sides of the lobe about one-third of its length from the anterior end, and a low median node may be present just posterior to a line connecting these furrows. Occipital furrow shallow, and occipital ring narrow. Basal lobes subtriangular in outline and undivided. Cheeks undivided and slope gently away from the glabella toward the anterior margin and steeply away toward the posterolateral margin. Border narrowest at the posterolateral corners of the cephalon and expands slightly forward. Surface of the cephalon smooth.

Pygidium slightly wider than long, nearly parallel-sided, broadly rounded posteriorly, and moderately arched transversely and longitudinally. Axial lobe nearly parallel-sided, about four-fifths the length and slightly less than one-half the width of the pygidium, strongly rounded posteriorly and undivided by furrows. It reaches nearly to the marginal furrow. Small, distinct median node situated on the axial lobe about one-third the length of the lobe from the anterior end of the pygidium. Pleural platforms narrow and downsloping from the axial lobe to the border. Marginal furrow broad and shallow. Border moderately wide and bears a pair of short, sharp lateral spines about opposite the posterior end of the axial lobe; surface smooth.

Discussion.—*K. seclusus* (Walcott) was described from the cranidium only. The type specimen is associated with *Modocia nevadensis* Palmer, n. sp., *Asaphiscus laeviceps* (Walcott), and *Holteria problematica* (Walcott) in USGS collection 58 (OS) from the Eureka district. A nearly identical cephalon and several associated pygidia of *K. seclusus* (Walcott) occur with these species in USGS collection 806 (CO) from the same area. The pygidia are considered to belong to the species and are described above.

The cephalon of this species is similar to that of *K. simplex* Resser from the lower Upper Cambrian but differs principally in having the anterior margin strongly rounded at the anterolateral corners and gently rounded across the front instead of evenly rounded. The pygidium is distinguished by having a nearly parallel-sided axial lobe.

Kobayashi (1939, p. 171) referred *A. seclusus* Walcott with doubt to *Geragnostus* (*Geragnostella*). He was apparently misled by the drawing in Walcott's monograph. Examination of the type shows that *A. seclusus* Walcott lacks the distinct anterior glabellar lobe characteristic of *Geragnostus* and *Geragnostella*.

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Occurrence.—Rare, Middle Cambrian, basal portion of the Hamburg limestone.

Figured specimens.—Holotype, cephalon, USNM 24586, length, 3 millimeters; cephalon, USNM 123353a, length, 2.5 millimeters; pygidium, USNM 123353b, length, 2.5 millimeters.

Genus PERONOPSIS Hawle and Corda, 1847

Peronopsis Hawle and Corda, 1847, Prodrom einer Monographie der bohmischen Trilobiten, p. 115.
Kobayashi, 1939, Tokyo Imp. Univ., Fac. Sci., Jour., sec. 2, v. 5, pl. 5, p. 115.
Westergard, 1946, Sveriges geol. undersökning, ser. C, no. 477, Årsbok 40, no. 1, p. 36.
Mesophenicus Hawle and Corda, 1847, op. cit., p. 46.
Diplorrhina Hawle and Corda, 1847, op. cit., p. 46.
Whitehouse, 1936, Queensland Mus. Mem., v. 11, p. 88.
Mesagnostus Jaekel, 1909, Deutsche Geol. Gesell. Zeitschr., Band 61, p. 398.
Quadragnostus Howell, 1935, Jour. Paleontology, v. 9, no. 3, p. 219.

Genotype.—*Battus integer* Beyrich, 1845 (p. 44).

Diagnosis.—Cephalon with glabella bilobed, tapered forward; no median longitudinal preglabellar furrow; basal glabellar lobes simple. Pygidium with axial lobe usually bluntly pointed posteriorly; length variable; transverse axial furrows shallow or absent; margin with or without a pair of posterolateral spines.

Discussion.—This genus is abundant and widespread in the Middle Cambrian rocks of the Great Basin. The bilobed glabella and the lack of a preglabellar median furrow on the cephalon and the posteriorly pointed, unfurrowed axial lobe on the pygidium distinguish it from other agnostids in the area.

Mesophenicus, *Diplorrhina*, *Mesagnostus*, and *Quadragnostus* were considered to be synonyms of *Peronopsis* by Kobayashi (1939, p. 115). There is no reason to question his conclusion.

Peronopsis interstrictus (White)

Plate 13, figure 6

Agnostus interstrictus White, 1874, U. S. Geog. and Geol. Surveys W. 100th Mer. Rept., p. 7.
White, 1877, U. S. Geog. and Geol. Surveys. W. 100th Mer. Rept., v. 4, p. 38, pl. 2, figs. 5a, b.
Walcott, 1886, U. S. Geol. Survey Bull. 30, p. 149, pl. 16, figs. 6, 6a.
Shimer and Shrock, 1944, Index Fossils of North America, p. 600, pl. 251, figs. 16–17.

Description.—The full description of this species given by White (1877, p. 38) cannot be improved upon.

Head and pygidium of almost exactly equal size and general shape and otherwise closely resembling each other.

Head a trifle broader than long, regularly rounded in front; sides at the postero-lateral regions subparallel; postero-lateral angles truncated; the whole exterior margin, including the truncated portions just named, provided with a narrow, raised rim the elevation of which forms a linear depression, or groove, between it and those portions of the head which it incloses; space between this marginal depression and the glabella a little wider posteriorly than it is in front, convex throughout, and its surface apparently smooth. Glabella conical, widest posteriorly, moderately convex, sides nearly straight, well defined by the dorsal furrows, abruptly rounded in front; a minute tubercle situated on the median line near the posterior end, and a shallow groove or furrow extending across near the front end, defining a frontal lobe of moderate size.

Thorax narrower than the head and pygidium, giving the body the appearance of being constricted at the middle; axial lobe broad, consisting of two segments, both of which are tumid at the ends adjoining the dorsal furrows; lateral lobes very narrow; pleurae almost as wide as long; each pleura tumid and rounded at its exterior end.

Pygidium having an outline like that of the head, and is also provided with a similar elevated marginal rim and linear depression within it; axial lobe a little longer than the glabella, and consequently that lobe reaches a little nearer the posterior margin of the pygidium than the glabella does to the anterior margin of the head, moderately convex in elevation and also in each lateral outline; a minute tubercle is situated on the median line near the anterior end, corresponding in size and relative position with the one on the glabella before mentioned; space between the dorsal furrows and the margin convex, its surface apparently smooth; upon the outer edge of the border of the pygidium, at each side and a little nearer to the axial extremity than to the antero-lateral angles, there is a minute protuberance, suggestive of an incipient spine. Besides the slight differences between the head and pygidium, already referred to, the pygidium differs also in having a faint appearance of segmentation of its axis and in a slight folding backward of the marginal rim at the antero-lateral angles.

Length of body, 8^{mm}; width of head and also of the pygidium, 5^{mm}; width of thorax, 4^{mm}.

Discussion.—The types of this species are slightly crushed but not badly distorted. The relatively large subtriangular anterior lobe of the glabella distinguishes the species from all other species of *Peronopsis*.

Kobayashi (1939, p. 120) placed *Agnostus interstrictus* White in *Armagnostus* Howell, which he considered a subgenus of *Peronopsis*. *Armagnostus* is now stated to be a synonym of *Homagnostus* Howell (Lochman and Duncan, 1944, p. 139). *A. interstrictus* White has all of the characteristics of *Peronopsis* and is retained in that genus. It lacks the preglabellar median furrow considered to be diagnostic of *Homagnostus*.

Occurrence.—Moderately common, Middle Cambrian, Wheeler formation, House Range, Utah, associated with *Elrathia kingii* (Meek), *Asaphiscus wheeleri* Meek, and *Bolaspidella* sp.

Figured specimen.—Holotype, complete carapace, USNM 15405, length, 8 millimeters.

Subfamily AGNOSTINAE Jaekel, 1909

Genus PTYCHAGNOSTUS Jaekel, 1909

Ptychagnostus Jaekel, 1909, Deutsche geol. Gesell. Zeitschr., Band 61, p. 401.

Kobayashi, 1939, Tokyo Imp. Univ., Fac. Sci., Jour., sec. 2, v. 5, pt. 5, p. 152.
Shimer and Shrock, 1944, Index Fossils of North America, p. 600.
Westergard, 1946, Sveriges geol. undersökning, ser. c, no. 477, Årsbok 40, no. 1, p. 67.

Genotype.—*Agnostus punctuosus* Angelin, 1851 (p. 8).

Diagnosis.—Cephalon with glabella bilobed, tapered forward; median longitudinal preglabellar furrow present; basal glabellar lobes simple or divided. Pygidium with axial lobe usually bluntly pointed posteriorly; anterior third separated from posterior portion and subequally divided by distinct transverse furrows; margin usually without posterolateral spines.

Ptychagnostus richmondensis (Walcott)

Plate 13, figures 4, 5

Agnostus richmondensis Walcott, 1884, U. S. Geol. Survey Mon. 8, p. 24, pl. 9, fig. 10.
Agnostus bidens Walcott [not Meek], 1884, idem, p. 26, pl. 9, figs. 13, 13a.

Diagnosis.—Cephalon with cheeks scrobiculate; basal glabellar lobes divided; long posterolaterally curved postcephalic spines present. Pygidium with axial lobe bluntly pointed posteriorly, reaching nearly to border; width about equal to that of pleural lobes; posterolateral marginal spines absent.

Description.—The cephalon is about as wide as long, slightly expanded forward, strongly rounded anteriorly and moderately arched transversely and longitudinally. The glabella is about three-fourths the length and one-third the width of the cephalon, tapered evenly forward, and bluntly pointed anteriorly. The anterior lobe is subtriangular in outline, only slightly elevated above the cheeks, about one-third the length of the glabella, and separated from the posterior lobe by a distinct transverse furrow. The posterior lobe rises to a high point near the posterior margin. A pair of short furrows notch the sides of the lobe about one-third of its length from the anterior end. A low median node is situated between the anterior tips of the basal lobes. The occipital furrow is distinct, and the occipital ring is narrow, with a small median node. The basal lobes are elongate subtriangular in outline, with a distinct shallow transverse furrow about one-third the length of each lobe from its anterior end. A median longitudinal furrow extends from the front of the glabella to the anterior border. The cheeks slope gently away from the glabella towards the anterior margin and steeply away towards the posterolateral margin. Furrows of varying lengths frequently alternating long and short extend most of the distance from the border across the cheeks towards the glabella. The pattern of the furrows varies from specimen to specimen and is often different on the right and left cheeks of the same specimen. The border is narrow, distinct, and of even width. Long slender postcephalic spines extend backward from the posterior margin of well-preserved specimens. The surface of the cephalon is smooth.

The pygidium is slightly wider than long, nearly parallel-sided, broadly rounded posteriorly, and moderately arched transversely and longitudinally. The axial lobe is about four-fifths the length and two-fifths the width of the pygidium and divided by 2 strong transverse furrows into 3 segments. The anterior segment is short, and the dorsal furrow along the lateral margins diverges forward. The second segment is longest on the axial line and is bounded distally by nearly parallel portions of the dorsal furrow. A distinct, slightly elongate median node is situated at the posterior margin of this segment. The posterior segment, which is nearly twice the combined length of the first 2 segments, tapers to a blunt point that is connected to the margin by a longitudinal furrow on many specimens. The pleural platforms are downsloping from the axis and do not bear radial furrows as do the corresponding portions of the cephalon. The border is distinct, slightly wider than that of the cephalon, and without marginal spines. A pair of short, blunt, anteriorly directed spines is present on the anterior margin of the pygidium. The surface of the pygidium is smooth.

Discussion.—This species was described from the cranidium only. Recent collections contain many cranidia and associated pygidia that unmistakably belong to it. Walcott's original specimen could not be located in the U. S. National Museum collections, but there is no doubt from his description and figure that the specimens described here are conspecific with it.

Vogdes (1892, p. 389) considered this species to be a synonym of *A. americanus* Billings. Kobayashi (1939, p. 165) rightly questioned this assignment and suggested that *A. richmondensis* Walcott might belong to *Lotagnostus* Whitehouse; however, it lacks the prominent transverse trilobation of the axial lobe of the pygidium of that genus. The preglabellar median furrow on the cephalon and the posteriorly pointed axial lobe of the pygidium suggest that this species belongs to *Ptychagnostus* Jaekel.

Ptychagnostus richmondensis (Walcott) is nearly identical to *P. atavus* (Tullberg), originally described from the zone of that name in the *Paradoxides proxissimus* stage of the Middle Cambrian of Sweden and subsequently reported by Whitehouse (1936, p. 85) and confirmed by Westergard (1946, p. 76) from the *Dinesus* stage of the Middle Cambrian of Australia. The principal difference exhibited by *P. richmondensis* (Walcott) is the presence of long postcephalic spines.

These have not been reported for *P. atavus* (Tullberg). In all other respects the analysis given by Whitehouse for *P. atavus* (Tullberg) fits the Nevada specimens perfectly.

The specimens illustrated by Walcott as *Agnostus bidens* Meek are not even congeneric with Meek's species; and, in addition, the illustrated "cephalon" is a pygidium as suspected by Kobayashi (1939, p. 161). Kobayashi, however, misinterpreted the drawings of the Eureka specimens and erroneously assigned the pygidium (Walcott, 1884, fig. 13a) to *Agnostus* and the "cephalon" (Walcott, 1884, fig. 13) to *Geragnostus*. Both specimens are pygidia of *P. richmondensis* (Walcott).

The type specimens of *A. bidens* Meek belong to the genus *Peronopsis*.

Occurrence.—Moderately common, Middle Cambrian, Geddes limestone of Wheeler and Lemmon (1939) Eureka district, Nev.

Figured specimens.—Cephalon, USNM 123354, length (not including spines), 3 millimeters; pygidium, USNM 123355, length 3 millimeters.

Superfamily CORYNEXOCHOIDEA Kobayashi, 1935

Rasetti (1948, 1951) has discussed the suprageneric classification within this superfamily in some detail. The writer has used that classification wherever possible.

Family DORYPIGIDAE Kobayashi, 1935

Genus OLENOIDES Meek, 1877

Olenoides Meek, 1877, U. S. Geol. Expl. 40th Par. Rept. v. 4, p. 25.
Kobayashi, 1935, Tokyo Imp. Univ., Fac. Sci., Jour., sec. 2, v. 4, pt. 2, p. 152 [complete synonymy].
Neolenus Matthew, 1899, Royal Soc. Canada Proc. and Trans., 2d ser. v. 5, sec. 4, p. 52 [see Kobayashi, 1935, idem for references to that date].
Lake, 1938, Paleontographical Soc., v. 91, p. 260.

Genotype.—Paradoxides? nevadensis Meek, 1870 (p. 62).

Diagnosis.—Cephalon subsemicircular in outline; posterior margin nearly straight; genal spines originating from posterolateral corners. Cranidium subtrapezoidal in outline. Glabella parallel sided or slightly expanded forward, prominently elevated above cheeks, reaching to border, smooth or faintly furrowed, well defined by dorsal furrow. Occipital furrow distinct. Occipital ring usually bears median spine. Fixed cheeks narrow, less than one half width of glabella. Ocular ridges distinct, strongly backswept from anterolateral margin of glabella. Distinct pits are present in dorsal furrow at junction with ocular ridge. Palpebral lobes small, situated opposite middle third of glabella. Posterior limbs long, wide; marginal furrow distinct.

Thorax consists of about seven segments. Axial portion of segments often with median node or spine. Pleural portions with distinct, posterolaterally directed furrow originating near inner anterior corner of lobe. Marginal spines sharp. Axial lobe gently to moderately tapered posteriorly.

Pygidium subsemicircular in outline. Axial lobe well defined by dorsal furrow, tapered posteriorly, reaching to or nearly to the inner margin of the border. Pleural lobes with distinct interpleural grooves and diagonal pleural furrows. Pleural furrows usually deepest. Margin with four or more pairs of posteriorly or posterolaterally directed, nearly horizontal spines.

Discussion.—Walcott (1925, p. 92) pointed out that the cranidia of *Neolenus* (*Olenoides*), *Kootenia*, and *Holteria*—the writer would also add *Dorypyge*—in the absence of the distinctive pygidia, could well be retained in one genus. The generic and specific characteristics in this group are almost entirely in the pygidia. Few cranidia show even distinctive specific characteristics. Many of the "species" of these genera described from cranidia alone have little scientific value unless a pygidium can be associated with them. Two of the three species discussed here were originated for cranidia. Fortunately, pygidia are associated with the type specimens so that useful diagnoses can be obtained.

Recent authors (Walcott, 1925; Kobayashi, 1935; Lake, 1938; and Rasetti, 1951) have had varying opinions about the relationships of *Olenoides* and *Neolenus* here considered synonyms.

The history of these opinions is well presented by Kobayashi (1935, p. 153, 154) and Lake (1938, p. 251–254). Most of the writers who expressed opinions, including Kobayashi and Lake, did not have the benefit of examination of the critical specimens. The following discussion is based upon a study of the genotypes of Olenoides and Neolenus.

Because of the fragmental nature of the only known specimen of *Olenoides nevadensis* (Meek), the genotype, the only parts capable of comparison with *Neolenus serratus* (Rominger), the genotype, are the thorax and pygidium. Meek's and Rominger's specimens are crushed but not otherwise distorted. Each specimen has seven thoracic segments. The axial lobe of the thorax of Rominger's specimen is not well preserved, but topotype specimens have a median node on each ring as does *O. nevadensis* (Meek). The axial lobe of *N. serratus* (Rominger) has a slightly greater rate of posterior taper than that of *O. nevadensis* (Meek); and accentuating their diagonal nature, the pleural furrows of the thoracic segments of Rominger's specimen are narrower than those of *O. nevadensis* (Meek).

The axial lobe of the pygidium of each type specimen is made up of four rings and a terminal segment; it does not reach the border. The principal differences between the specimens are the courses of the pleural furrows and interpleural grooves on the pleural platforms. On *N. serratus* (Rominger) the first pleural furrow and groove are nearly identical in their courses to those of the preceding thoracic segment. The second, third, and fourth pleural furrows make progressively smaller angles with the longitudinal axis of the pygidium. Each interpleural groove—the second, third, and fourth are discernible—curves more strongly backward than the one that precedes it. All segments of the pygidium, including that bearing the terminal portion of the axial lobe, bear sharp short marginal spines—totaling five pairs.

On the pygidium of *O. nevadensis* (Meek) the grooves and furrows are relatively broader than those of *N. serratus* (Rominger). The first pleural furrow and interpleural groove are also nearly identical in their courses to those of the preceding thoracic segment. The second, third, and fourth pleural furrows also make progressively smaller angles with the longitudinal axis of the pygidium. The third furrow, however, is nearly parallel to the longitudinal axis, and the fourth is continuous with the dorsal furrow. The interpleural grooves are adjacent to, behind, and parallel to the pleural furrows. The fourth groove is not discernible. The angle made by the third furrow and groove of *O. nevadensis* (Meek) with the longitudinal axis of the pygidium is distinctly smaller than that made by the fourth furrow and groove of *N. serratus* (Rominger). The margin of *O. nevadensis* (Meek) has been destroyed but probably bore at least four pairs of spines.

If only these two species were involved, a case might be made for keeping them in separate genera. Many other species of *Neolenus* and *Olenoides* have been described, however; and complete gradation between the distinctive characters of the two genotypes is present. The writer can see no objection to accepting the view of Kobayashi (1935, p. 154) that Rominger's and Meek's specimens represent distinct species of the same genus. In the writer's opinion, therefore, *Olenoides* Meek, 1877 (not *Neolenus* Matthew, 1899), although originated for a wholly inadequate specimen by present standards, is the correct designation for the genus under discussion.

Olenoides expansus (Walcott)

Plate 14, figures 5, 7

Dicellocephalus? expansus Walcott, 1884, U. S. Geol. Survey Mon. 8, p. 45, pl. 9, fig. 19.

Dolichometopus? expansus (Walcott). Walcott, 1916, Smithsonian Misc. Coll., v. 64, no. 5, p. 368, pl. 53, figs. 5, 5a.

Description.—Walcott (1884, p. 45) described the cranidium of this species in considerable detail.

Glabella elongate subquadrangular, or subclavate, the base about one-fifth narrower than the front; surface convex and without perceptible furrows; occipital furrow distinctly defined; occipital ring strong, with a small spine on the center of the posterior portion; dorsal furrows well defined along the sides of the glabella; fixed cheeks of medium width, palpebral lobes unknown; an ocular (?) ridge crosses the anterior portion of the right fixed cheek, so as to indicate a moderate sized eyelobe between it and the postero-lateral limb; frontal limb as a narrow rim; postero-lateral limbs rather narrow, extended and marked by a strong furrow within the posterior margin.

An associated pygidium, lacking the right pleural lobe is used for the following description. Pygidium subsemicircular in outline. Axial lobe elongate, well defined by dorsal furrow, extending nearly to posterior margin, consisting of four distinct segments and a partially divided terminal portion, and bluntly rounded posteriorly. Dorsal furrows slightly convergent posteriorly adjacent to the two anterior segments, parallel behind the second segment. Pleural lobes marked by strong pleural furrows and weak interpleural grooves. Four pleural furrows and three pleural grooves are visible. The fourth pleural furrow makes a sharp angle with the dorsal furrow. Anteriorly, the furrows make progressively larger angles with the dorsal furrow. The first two interpleural grooves and the last two pleural furrows end near the margin in distinct subcircular depressions. Four pairs of marginal spines are present. The two anterior pairs are moderately long and slender. The third pair is more than twice the length and diameter of the anterior spines. The fourth pair is represented by small nubs along the margin.

The surface of the specimen is smooth.

Discussion.—The pygidium of this species has not previously been described. A pygidium bearing the same museum and locality numbers as the type cranidium is associated with it in the U. S. National Museum collections. On the basis of this association, the assignments of the species, by Walcott (1916, p. 368) to *Dolichometopus* and by Kobayashi (1942, p. 152) to *Dolichometopsis* (*Ptarmigania*), are incorrect and only serve to illustrate the difficulty of accurate systematic placement of cranidia of the Dorypygidae without knowledge of the associated pygidia. Resser (1938b, p. 37) assigned the species to *Olenoides*, but without giving any explanation for his decision.

The distinguishing characteristics of the species are the axial lobe of the pygidium, which consists of four segments and a partially divided terminal portion, the strong development of the third pair of marginal spines, and the weak development of the fourth pair.

Occurrence.—Middle Cambrian, Geddes limestone of Wheeler and Lemmon (1939) Eureka district, Nev.

Figured specimens.—Cranidium, USNM 15450, length, 13 millimeters; pygidium, USNM 15450, length, 14 millimeters.

Olenoides nevadensis (Meek)

Plate 14, figure 9

Paradoxides? nevadensis Meek, 1870, Acad. Nat. Sci. Philadelphia Proc., p. 62.
Meek, 1877, U. S. Geol. Expl. 40th Par. Rept. v. 4, p. 23, pl. 1, fig. 5.
Olenoides nevadensis (Meek), Walcott, 1886, U. S. Geol. Survey Bull. 30, p. 181, pl. 25, fig. 7.
Walcott, 1913, Carnegie Inst. Washington Pub. 54, v. 3, pl. 8, fig. 7.
Shimer and Shrock, 1944, Index Fossils of North America, pl. 256, fig. 18.

Discussion.—The type and only known specimen is discussed under the genus. The distinctive characteristics of the species are the axial lobe, which consists of four segments and a terminal portion, and the sharp angle made by the third pleural furrow with the longitudinal axis of the pygidium.

Occurrence.—Middle Cambrian, Wheeler formation, House Range, Utah.

Figured specimen.—Holotype, incomplete carapace, USNM 15453, length, 69 millimeters.

Olenoides wahsatchensis (Hall and Whitfield)

Plate 14, figures 6, 8

Dikellocephalus wahsatchensis Hall and Whitfield, 1877, U. S. Geol. Expl. 40th Par. Rept., v. 4, p. 241, pl. 1, fig. 35.
Dikellocephalus? gothicus Hall and Whitfield, 1877, idem, p. 242, pl. 1, fig. 36.
Olenoides wahsatchensis (Hall and Whitfield), Walcott, 1886, U. S. Geol. Survey Bull. 30, p. 189, pl. 29, figs. 2, 2a.
Resser, 1939, Smithsonian Misc. Coll., v. 97, no. 12, p. 14, pl. 4, figs. 1, 2.

Description.—Hall and Whitfield (1877, p. 241, 242) described this species in considerable detail.

Glabella elongate-quadrangular, with parallel lateral margins and slightly-rounded front; height and width about as four to three; very depressed-convex, and marked by two pairs of transverse furrows, which do not quite meet in the center, dividing the glabella into three nearly equal portions. Occipital furrow narrow, not strongly defined; ring narrow, distinct, and bearing a slender spine on the center; dorsal furrows narrow and poorly defined.

Fixed cheeks wide and flattened; ocular ridges faintly marked, rising opposite the anterior furrow of the glabella, and directed slightly backward to the eye-lobe. Frontal limb very short and wide, the marginal rim regularly arcuate, narrow, and prominent, closely cutting the front of the glabella. Facial sutures not fully determined, but are distinct on the anterior margin, cutting the rim with a strong outward curvature, and again recurving to the eye, leaving the limb nearly two-thirds as wide at its widest point as the glabella.

Pygidium semi-ovate, or short paraboloid, with a very strong central axis, and spinose margin; anterior margin straightened for about two-thirds the width of the lateral lobes, where it curves abruptly backward to the lateral angles. Axial lobe strong, cylindrical, and prominent, forming one-third of the entire width exclusive of the spines, and reaching almost to the posterior margin of the shield; obtusely rounded at the extremity, and marked by six annulations exclusive of the terminal ones. Lateral lobes very moderately convex, and marked by four divided ribs on each side, each terminating in a strong and proportionally long marginal spine; central area of each rib depressed, forming a flattened groove, extending to the base of the marginal spine. Borders of the ribs elevated, the anterior one strongest and prominent, gradually widening from its origin to the margin of the shield; posterior border narrow and rounded, separated from the next succeeding rib by a sharply-depressed, narrow groove. This peculiar form of rib gives to the shield an appearance similar to the groining of a Gothic arch. Margin of the shield surrounded by twelve long, rather strong spines, four of which, on each side, are about equal in size and strength, while the four occupying the posterior border are shorter and unequal, those in the middle being the shortest.

Discussion.—Walcott (1886, p. 189) pointed out that *Dikellocephalus? gothicus* Hall and Whitfield is the pygidium of *O. wahsatchensis* (Hall and Whitfield). There are several features of the original descriptions of this and the cranidium that are not accurate. The glabellar furrows are depressions, owing primarily to crushing. Well-preserved specimens probably would exhibit only shallow furrows if any at all. There are 5 rather than 6 axial segments exclusive of the terminal one on the pygidium. The original authors apparently considered the articulating ring of the first segment as a separate segment.

The pygidium is similar to *O. serratus* (Rominger), differing in having one more axial segment and one more pair of marginal spines. The four long lateral pairs of spines and two short posterior pairs distinguish this species from others with six pairs of spines.

Occurrence.—Middle Cambrian, Spence shale member of Ute limestone Wasatch Range, Utah.

Figured specimens.—Holotype cranidium, USNM 15447, length, 15 millimeters; pygidium, USNM 15447, length (not including spines), 15 millimeters.

Genus KOOTENIA Walcott, 1889

Kootenia Walcott, 1888, Am. Jour. Sci. 3d ser., v. 36, no. 213, p. 446.
Walcott, 1925, Smithsonian Misc. Coll., v. 75, no. 3, p. 92.
Kobayashi, 1935, Tokyo Imp. Univ., Fac. Sci., Jour., sec. 2, v. 4, pt. 2, p. 156.
Shimer and Shrock, 1944, Index Fossils of North America, p. 613.

Genotype.—*Bathyuriscus* (*Kootenia*) *dawsoni* Walcott, 1889 (p. 446).

Diagnosis.—Like *Olenoides* but with only pleural furrows visible on the pleural platforms of the pygidium.

Kootenia quadriceps (Hall and Whitfield)

Plate 14, figures 1–3

Dikellocephalus quadriceps Hall and Whitfield, 1877, U. S. Geol. Expl. 40th Par. Rept., v. 4, p. 240, pl. 1, figs. 37–40.
Olenoides quadriceps (Hall and Whitfield), Walcott, 1886, U. S. Geol. Survey Bull. 30, p. 187, pl. 29, figs. 1, 1a–c.
Olenoides quadriceps (Hall and Whitfield), Walcott, 1890, U. S. Geol. Survey 10th Ann. Rept. pt. 1, p. 646, pl. 94, figs. 4, 4a–b.

Description.—Hall and Whitfield (1877, p. 240) described this species in considerable detail.

Glabella and fixed cheeks united, quadrangular in form, with a regularly and symmetrically arcuate front margin. Glabella elongate quadrangular, a little expanded and rounded in front, three-fourths as wide across the middle as the length above the occipital furrow, very gibbous or somewhat inflated; marked by three pairs of transverse furrows, which extend about three-fourths of the distance to the center, not in the least oblique, and so faint as to be detected only on the closest examination, or by the reflection of light along the surface; occipital furrow very distinct; ring strong and robust, supporting a strong, thickened spine of undetermined length on the posterior margin. The base of the spine is broad, and the spine directed backward and upward.

Fixed cheeks of moderate size, strongly convex, a little more than one-third as wide at the eye as the width of the glabella, and rapidly declining to the antero-lateral angles. Eye-lobes small, situated rather behind the middle of the length of the head; ocular ridges distinct, strongly directed forward in their passage from the eye to the glabella. Frontal limb very short, not extending beyond the frontal margin of the glabella, and strongly curving backward to the point of intersection with the facial sutures.

Facial sutures commencing at the anterior margin on a line with the inner angle of the eye-lobe, and running directly back to the eye in a straight line; behind the eye, the direction is outward, but its exact course has not been ascertained. Lateral limb not observed.

A pygidium associated with the glabella is paraboloid in form, and surrounded on the margins by twelve short, rather strong spines, the four on the posterior margin being shorter than the others. Axis narrow, highly convex, two-thirds as long as the shield, and marked by four rings, exclusive of the terminal ones. Lateral lobes broad, convex, and marked by four low, rounded ribs, the anterior one much narrower than the others; each of the four ribs terminating in one of the lateral spines.

Discussion.—As pointed out by the original authors, this species is similar to *Dikellocephalus? gothicus* Hall and Whitfield (=*Olenoides wahsatchensis* (Hall and Whitfield.)) The principal distinguishing feature is the shallow nature of the interpleural grooves on the pygidium. *D. quadriceps* Hall and Whitfield was placed in *Kootenia* by Resser (1937, p. 16) without comment.

The specimen from the Eureka district, Nev., figured as *Dikellocephalus? quadriceps* Hall and Whitfield by Walcott (1884, pl. 9, fig. 24) is a small fragmentary cranidium that may not belong to the species. Resser (1937, p. 15) placed it in a new species *Kootenia eurekensis* Resser, but until a pygidium is found there is no assurance that it even belongs in *Kootenia*. His diagnosis, "Compared with *K. quadriceps* this species is much shorter.", is totally inadequate. The significance of slight differences in proportion in such small samples is open to serious question. *K. eurekensis* Resser definitely differs from *K. quadriceps* (Hall and Whitfield) by lacking an occipital spine; but, in terms of present knowledge of trilobites of this family, more information than that is needed to erect a new species. Taxonomically speaking, Walcott's specimen is specifically and generically unidentifiable. For this reason the name *Kootenia eurekensis* Resser, 1937, should be restricted to the holotype numbered 15449 in the collections of the U. S. National Museum.

Occurrence.—Middle Cambrian, Ute limestone, Bear River Range, Utah.

Figured specimens.—Cotypes: Cranidium, USNM 15448a, length, 6.5 millimeters; pygidium, USNM 15448b, length (not including spines) 8.5 millimeters; pygidium, USNM 15448c, length (not including spines) 10 millimeters.

Genus HOLTERIA Walcott, 1924

Holteria Walcott, 1924, Smithsonian Misc. Coll., v. 75, no. 2, p. 57.
Walcott, 1925, idem, no. 3, p. 91.
Shimer and Shrock, 1944, Index Fossils of North America, p. 611.

Genotype.—*Ogygia? problematica* Walcott, 1884 (p. 63, pl. 10, figs. 2, 2a, b, 4).

Diagnosis.—Cranidium like *Olenoides* Meek. It differs from typical forms of that genus by having the anterior end of the glabella overhanging the anterior margin, a shallow occipital furrow, but no occipital spine.

Pygidium with axial lobe moderately well defined, narrow, three-fourths or more the length of pygidium, consisting of four segments and a rounded terminal portion. Pleural lobes consisting of four segments; distinct pleural furrows and interpleural grooves present; pleural furrows parallel and adjacent to groove marking posterior margin of each pleural segment. First and second pleural segments rapidly expanding distally, second segment largest, and extended into moderately long, straight, posterolaterally directed marginal spines; second pair of marginal spines originates posterior to end of axial lobe. Third pleural segment narrower than second segment; pleural furrow and interpleural groove nearly parallel to dorsal furrow. Fourth pleural segment, when discernable, less than one-third width of third segment, poorly defined, approximately parallel to dorsal furrow. Third and fourth segments not extended into marginal

spines. Posterior margin of pygidium between spines of second pleural segment, curved gently forward.

Discussion.—The cranidium of this genus resembles that of *Olenoides inflatus* (Walcott) (1908, p. 30). It differs principally by lacking a strong occipital spine. The pygidium is unlike that of any other known trilobite. Walcott (1925, p. 92) stated that this was an Upper Cambrian genus. The associated trilobite fauna does not support his conclusion. *Modocia nevadensis* Palmer, n. sp., and *Asaphiscus laeviceps* (Resser) are congeneric or conspecific with trilobites from the Middle Cambrian Secret Canyon shale. Only *Kormagnostus seclusus* (Walcott) has Upper Cambrian affinities.

Holteria problematica (Walcott)

Plate 15, figures 3, 4, 6

Ogygia? problematica Walcott, 1884, U. S. Geol. Survey Mon. 8, p. 63, pl. 10, figs. 2, 2a, b, 4.

Holteria problematica (Walcott). Walcott, 1924, Smithsonian Misc. Coll., v. 75, no. 2, p. 57, pl. 13, fig. 7.

Walcott 1925, idem, v. 3, p. 93, text fig. 13; pl. 15, figs. 17–21.

Shimer and Shrock, 1944, Index Fossils of North America, pl. 259, figs. 20, 21.

Diagnosis.—As this is the only described species of the genus, its characters are those of the genus.

Discussion.—The two pairs of broad marginal spines and the character of the segmentation on the pleural lobes of the pygidium distinguish this species from all other known trilobites.

Occurrence.—Middle Cambrian, lower part of the Hamburg limestone, Eureka district, Nev.

Figured specimens.—Cotypes: Immature cranidium, USNM 24606, length, 3 millimeters; adult cranidium, USNM 24606, length, 23 millimeters; pygidium, USNM 24606, length, 19 millimeters.

Family DOLICHOMETOPIDAE Walcott, 1916

Genus ATHABASKIA Raymond, 1928

Athabaskia Raymond, 1928, Am. Jour. Sci. 5th ser., v. 15, no. 88, p. 311.

Kobayashi, 1942, Tokyo Imp. Univ., Fac. Sci. Jour., sec. 2, v. 6, pt. 10, p. 156.

Lochman, 1952, Smithsonian Misc. Coll., v. 119, no. 1, p. 128.

Genotype.—*Athabaskia ostheimeri* Raymond, 1928 (p. 311).

Diagnosis.—Cephalon subsemicircular in outline; posterior margin straight; distinct genal spines extend backward from posterolateral corners. Cranidium with glabella extending to or nearly to anterior margin, straight sided behind next to last glabellar furrow, distinctly expanded anterior to this furrow; anterolateral corners strongly rounded; anterior margin broadly rounded. Three pairs of straight glabellar furrows visible; posterior pair extended backward at a sharp angle with dorsal furrow; middle pair approximately perpendicular to dorsal furrow; anterior pair extended forward from dorsal furrow. Occipital furrow distinct, deepest at sides. Occipital ring flat, unspined. Width of fixed cheeks about one-third width of glabella. Palpebral lobes long, distinct; anterior ends nearly touching dorsal furrow in front of first distinct glabellar furrow. Posterior limbs longer than occipital ring, narrow.

Thorax of 7 or 8 segments. Axial lobe narrower than pleural lobes. Pleural lobes of each segment subequally divided by broad pleural furrow and extended distally into a short pointed spine.

Pygidium subsemicircular in outline, nearly as large as cephalon. Axial lobe prominent, furrowed, about as wide as pleural platforms, not extended onto concave border. Pleural lobes with pleural furrows and interpleural grooves about equally spaced, usually extended onto border.

Discussion.—The cranidium of this genus is similar to that of *Bathyuriscus* and for this reason Kobayashi (1942, p. 156) considered it only a subgenus of *Bathyuriscus*. Resser (1935, p. 20) placed the genus in synonymy with *Clavaspidella*. The writer agrees with Rasetti (1951, p. 156) and Lochman (1952, p. 128) who have considered *Athabaskia* to be distinct from both *Bathyuriscus* and *Clavaspidella*. The relationships of the genus to *Clavaspidella* are discussed and analysed by Lochman (1952, p. 128).

Athabaskia howelli (Walcott)

Plate 13, figure 8

Bathyuriscus howelli Walcott, 1886, U. S. Geol. Survey Bull. 30, p. 216, pl. 30, figs. 2, 2a.

Pack, 1906, Jour. Geology, v. 14, no. 4, p. 296, pl. 2, figs. 2, 2a.

Walcott, 1916, Smithsonian Misc. Coll., v. 64, no. 5, p. 343, pl. 47, figs. 1, 1b.

Clavaspidella howelli (Walcott). Shimer and Shrock, 1944, Index Fossils of North America, p. 609, pl. 259, fig. 3.

Description.—Walcott (1886, p. 216) described this species in considerable detail.

General form ovate. Entire form of head unknown, but from the parts preserved it appears to have been semicircular. Glabella clavate, expanding in front of the second pair of glabellar furrows; posteriorly the sides are subparallel to the occipital segment; the posterior pair of glabellar furrows are directed obliquely backward nearly to the occipital furrow; the second pair are less obliquely inclined backward, and the third pair penetrate directly in, one-third the distance on each side. Occipital furrow well defined; occipital ring rounded and rather strong. Eyes large, lunate, the extremities close to the glabella. Fixed cheeks very narrow; postero-lateral limbs narrow elongate; frontal limb narrow, slightly convex, and expanding but little in front of the glabella. The facial sutures cut the anterior margin and trend obliquely in to the anterior end of the eyes; encircling the large palpebral lobes, they extend outward from the posterior ends of the eyes and cut the posterior margin of

the head well out towards the genal angle. Free cheeks unknown.

Thorax with eight segments. Axial lobe convex, tapering very gradually from the anterior segments to the pygidium; each segment is well defined and arches slightly forward; pleural lobes moderately convex; the segments curve gently backward from the genal angle and terminate in short falcate points; pleural groove rather broad and deep, and continued nearly to the extremity of the segment.

Pygidium subelliptical in outline; axis prominent, elongate, subconical, divided by four transverse furrows into four rings and a terminal segment; the pleural lobes are less convex, and, towards the margin, flattened out so as to form a broad, slightly convex border across which the four anchylosed segments, with their pleural grooves well defined, extend nearly to the margin.

Surface not preserved so as to show any surface striae.

Dimensions: Length of entire body, 23 mm; head, 9 mm; thorax, 8 mm; pygidium, 6 mm.

Discussion.—This species is characterized by having the anterior ends of the palpebral lobes reaching nearly to the dorsal furrow and the border of the pygidium about as wide as the greatest width of the pleural platform.

Occurrence.—Middle Cambrian, Chisholm shale, Pioche, Nev.

Figured specimen.—Holotype, USNM 15457, length, 23 millimeters.

Genus GLOSSOPLEURA Poulsen, 1927

Glossopleura Poulsen, 1927, Meddelelser om Grönland, Bind 70, p. 268.
Kobayashi, 1935, Tokyo Imp. Univ., Fac. Sci., Jour., sec. 2, v. 4, pt. 2, p. 132.
Kobayashi, 1942, idem, v. 6, pt. 10, p. 159.
Shimer and Shrock, 1944, Index Fossils of North America, p. 611.
Sonoraspis Stoyanow, 1952, Smithsonian Misc. Coll., v. 119, no. 1, p. 50.

Genotype.—Dolichometopus boccar Walcott, 1916 (p. 363, pl. 52, figs. 1, 1a–f).

Diagnosis.—Cephalon subsemicircular in outline; posterior margin straight; distinct genal spines extend backward from posterolateral corners. Cranidium with glabella moderately well to poorly defined by dorsal furrow, extended to anterior margin, slightly expanded forward or of nearly constant width. Glabellar furrows shallow or absent; when visible, four pairs usually present. Occipital furrow shallow. Occipital ring flat, unspined. Border absent. Brim, when present, narrow, only at sides of glabella. Fixed cheeks about one-half width of glabella; palpebral lobes long, poorly defined; anterior ends nearly touching dorsal furrow, posterior ends about opposite occipital furrow. Posterior limbs narrow, about as long as occipital ring; marginal furrow shallow.

Free cheek with evenly rounded margin and prominent genal spine. Border differentiated from ocular platform, variable in width.

Thorax of 7 or 8 segments. Axial lobe prominent, width equal to or less than that of pleural lobes. Pleural lobes of each segment subequally divided by pleural furrow. Segments terminate distally in short, sharp spines.

Pygidium subsemicircular in outline about as large as cephalon. Axial lobe prominent, tapered slightly posteriorly, reaching to or onto broad, flat or concave border. Furrows on axial and pleural lobes shallow or absent.

Discussion.—This genus is characterized by the shallow nature of all furrows on the cephalon and pygidium, the poorly developed frontal area, long palpebral lobes on the cranidium, and the broad flat or concave border on the pygidium.

Sonoraspis (Stoyanow, 1952, p. 50) is based on poorly preserved material that differs from *Glossopleura* by having 8 instead of 7 thoracic segments. The writer does not consider this sufficient justification for generic distinction, especially with the inadequate knowledge available concerning variation of this feature within a population. *Sonoraspis* is considered here to be a synonym of *Glossopleura*.

Glossopleura producta (Hall and Whitfield)

Plate 13, figures 7, 9–13

Ogygia producta Hall and Whitfield, 1877, U. S. Geol. Expl. 40th Par. Rept. v. 4, p. 244, pl. 2, figs. 31–34.
Ogygia parabola Hall and Whitfield, 1877, idem, p. 245, pl. 2, fig. 35.
Bathyuriscus productus (Hall and Whitfield). Walcott [part], 1886, U. S. Geol. Survey Bull. 30, p. 217, pl. 30, figs. 1e, 1f, and 1i.
Dolichometopus productus (Hall and Whitfield). Walcott [part], 1916, Smithsonian Misc. Coll., v. 64, no. 5, pl. 53, figs. 2, 2a–e.

Description.—Glabella elongate, slightly expanded forward, reaching to anterior margin, bearing slight median longitudinal keel, well defined by dorsal furrow. Glabellar furrows indistinct. Occipital furrow broad, moderately deep. Occipital ring broad. Character of brim in front of palpebral lobes not known. Fixed cheeks about one-half of glabella on line through midpoints of palpebral lobes. Palpebral lobes about two-thirds length of glabella, narrow, curved, slightly depressed below level of cheek, anterior ends adjacent to dorsal furrow, posterior ends opposite occipital furrow about one-third width of glabella from dorsal furrow. Posterior limbs about equal in length to occipital ring, narrow. Marginal furrow broad, shallow.

Free cheek elongate subtriangular in outline, margin gently curved. Border narrow, separated from broad

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ocular platform by shallow marginal furrow. Faint suggestion of a genal spine. Eyes large, situated towards anterior end of cheek.

Thorax subquadrate in outline, consisting of seven segments. Axis tapered slightly backward, well defined by dorsal furrow, somewhat less than one-third width of thorax. Pleural lobes of each segment flattened and pointed distally. Pleural furrows broad, shallow, situated slightly anterior to middle of segment.

Pygidium subsemicircular in outline. Axis elongate, well defined by dorsal furrow, reaching to or onto concave border, anterior width slightly more than one-fourth that of pygidium. Axial segments 6 or 7 poorly defined. Pleural platforms faintly furrowed. Border concave, of nearly constant width, slightly less than one-third width of pleural lobe at anterior margin.

Discussion.—It is unfortunate that some of the oldest name-bearing trilobite specimens are represented by such poor material as is *G. producta* (Hall and Whitfield). The type cranidium is laterally compressed, lacks the anterolateral margins and posterior limbs, and shows only broken portions of the fixed cheeks. The pygidium is longitudinally compressed but is otherwise in relatively good condition. Laterally compressed pygidia in the same collection have an entirely different appearance as pointed out by Walcott (1886, p. 218). *Ogygia parabola* Hall and Whitfield, from the same beds as *O. producta* Hall and Whitfield, is a laterally compressed pygidium of that species. Because of the distorted nature of the compressed shale specimens, specific comparisons have little value.

It is not the purpose of this paper to review the numerous species assigned to *Glossopleura* in the past two decades. Resser was certainly correct in assigning *Ogygia producta* Hall and Whitfield to the genus. In fact, the differences between *G. producta* Hall and Whitfield and the genotype *G. boccar* (Walcott), also represented by poor material, are so slight as to raise the question of their recognition as different species. For the purposes of accurate paleontology and until the species is described from better material, the use of the name *Glossopleura producta* (Hall and Whitfield) should be confined to the type specimens.

Occurrence.—Middle Cambrian, Ophir shale?, Oquirrh Range, Utah.

Figured specimens.—Cotypes: Incomplete carapace, USNM 15456c, length, 33 millimeters; cranidium, USNM 15456a, length, 17 millimeters; pygidium, USNM 15456e, length, 13 millimeters; free cheek, USNM 15456b, width, 12 millimeters. Other specimens: Incomplete carapace, USNM 123356, length, 25 millimeters; holotype of *O. parabola*, USNM 15456d, length, 24 millimeters.

Family ORYCTOCEPHALIDAE Beecher, 1897

Genus ORYCTOCEPHALUS Walcott, 1886

Oryctocephalus Walcott, 1886, U. S. Geol. Survey Bull. 30, p. 210.
Reed, 1910, India Geol. Survey Mem., ser. 15, v. 17, mem. 1, p. 10.
Kobayashi, 1935, Tokyo Imp. Univ., Fac. Sci., Jour., sec. 2, vol. 4, pt. 2, p. 146.
Shimer and Shrock, 1944, Index Fossils of North America, p. 615.

Genotype.—*Oryctocephalus primus* Walcott, 1886 (p. 210, pl. 29, figs. 3, 3a).

Diagnosis.—Cranidium with glabella prominent, nearly parallel sided, extended to border. Glabellar furrows marked by three pairs of pits often connected by shallow furrows across top of glabella but not connected to dorsal furrow. Occipital furrow distinct, with deep pits near dorsal furrow. Brim not present in front of glabella. Border flat, short. Width of fixed cheek one-half or more width of glabella. Palpebral lobe moderately large, opposite middle third of glabella, connected to dorsal furrow by distinctly to poorly defined ocular ridge. Facial suture straight forward in front of palpebral lobe, divergent behind.

Free cheek narrow, margin evenly rounded. Border well defined by marginal furrow, extended posteriorly into genal spine.

Thorax of 6 or 7 segments. Axial lobe prominent, width greater than one-half width of pleural lobes. Pleural lobe of each segment with deep diagonal pleural furrow; distal spines of variable length.

Pygidium subsemicircular in outline, consisting of 5 segments and a small terminal portion. All segments visible on axial and pleural lobes; pleural furrows deeper than interpleural grooves. Each segment extended distally into a marginal spine.

Discussion.—The cranidium of this genus is characterized by the elongate glabella with three pairs of pits representing the glabellar furrows. The pygidium, which has the principal diagnostic generic features, differs from the pygidia of other members of the family by having pleural furrows, interpleural grooves visible, and marginal spines.

Oryctocephalus primus Walcott

Plate 15, figures 1, 2

Oryctocephalus primus Walcott, 1886, U. S. Geol. Survey Bull. 30, p. 210, pl. 29, figs. 3, 3a.
Walcott, 1890, U. S. Geol. Survey 10th Ann. Rept., pt. 1, p. 653, pl. 95, figs. 4, 4a.

Diagnosis.—Pygidium with long, slender marginal spines.

Description.—Walcott (1886, p. 210) described this species in considerable detail as follows:

Entire head as restored by the union of the free cheeks to the

central portions of the head, transverse subsemicircular. Glabella elongate, quadrilateral, sides parallel, front broadly rounded and, in some specimens, showing a slight indentation midway; surface marked by four transverse furrows that terminate in little pits within the margin of the glabella; a shallow depression unites the pits on each side within the margin, and there is on some glabellas a very shallow depression running obliquely backward from each pit to the axial furrow; the transverse furrows uniting the pits are strong and arch a little backward at the center; anteriorly a shallow pit occurs a little back of the antero-lateral angles of the glabella that opens out into the axial furrows; the occipital furrow is represented by the posterior pair of pits and connecting furrow, and the strong occipital segment is united to the glabella at each end within the axial furrows; axial furrows strongly defined.

Fixed cheeks nearly as broad as the glabella; they narrow slightly in front and broaden out posteriorly into the short postero-lateral limbs; frontal limb practically obsolete; a narrow raised margin borders the front of the head; palpebral lobe narrow and with a deep groove between it and the fixed cheek; a narrow ocular ridge crosses the fixed cheek from the palpebral lobe to the axial groove opposite the small anterior depressions on the side of the glabella. Free cheeks elongate, convex, bordered by a narrow rounded rim that extends backward as a short spine; visual surface of eye broken away.

Thorax unknown.

Associated pygidium with a strong axial lobe and divided into five rings and into a terminal elongate ring by five transverse furrows; pleural lobes strongly grooved by four anchylosed pleural segments that terminate in strong, elongate points; a fifth segment terminates in a point on each side of the posterior end of the axial lobe.

Discussion.—This is the only species occurring with *Kochaspis liliana* Walcott and *K. augusta* Walcott at their type locality.

Occurrence.—Middle Cambrian, Pioche formation, Pioche, Nev.

Figured specimens.—Cotypes: Cranidium, USNM 15427, length, 5 millimeters; pygidium, USNM 15427, length (not including spines) 5 millimeters.

Family ZACANTHOIDIDAE Swinnerton, 1915

Genus ZACANTHOIDES Walcott, 1888

Embolimus Rominger, 1887 [not *Embolemus* Westwood, 1833—Hymenoptera], Acad. Nat. Sci. Philadelphia Proc., p. 15.

Zacanthoides Walcott, 1888, Am. Jour. Sci. 3d ser., v. 36, no. 213, p. 165.

Kobayashi, 1935, Tokyo Imp. Univ., Fac. Sci., Jour., sec. 2, vol. 4, pt. 2, p. 123 [synonymy].

Shimer and Shrock, 1944, Index Fossils of North America, p. 619.

Genotype.—*Embolimus spinosa* Rominger, 1887 (p. 15, pl. 1, fig. 3).

Diagnosis.—Cephalon subsemicircular in outline; posterior margin straight; long genal spines extend outward and backward from lateral margins; short intergenal spines may be present at distal ends of posterior limbs on cranidium.

Cranidium with glabella moderately well defined by dorsal furrow, parallel sided, slightly expanded forward or slightly tapered forward, not reaching to anterior margin. Glabellar furrows variable in depth, 3 or 4 pairs usually visible. Occipital furrow distinct, straight. Occipital ring flat, with or without occipital spine. Frontal area short, broad, with depressed brim and raised border. Fixed cheeks about one-half width of glabella, semicircular in outline. Palpebral lobes narrow, well defined by palpebral furrow, long, curved; anterior ends adjacent to dorsal furrow opposite third pair of glabellar furrows anterior to occipital furrow; posterior ends opposite occipital furrow, about one-third width of glabella from dorsal furrow. Posterior limbs narrow, about as long as occipital ring, often with distinct, posteriorly directed spines at distal extremities. Facial sutures widely divergent anterior and posterior to palpebral lobe.

Free cheek with evenly rounded margin and distinct, narrow border. Long, slender genal spine directed outward and backward from lateral margin.

Thorax of 8 or 9 segments. Axial lobe as wide or wider than pleural lobes exclusive of spines. Pleural portion of each segment with two laterally converging marginal furrows that leave a triangular raised median portion near the dorsal furrow. Each segment extended distally into a long slender spine.

Pygidium smaller than cephalon with prominent furrowed axial lobe occupying one-third or more width of pygidium, extended nearly to posterior margin. Anterolateral corners of pygidium strongly rounded. Posterior margin with three or more pairs of posteriorly directed spines of varying lengths.

Discussion.—Although this genus has been mentioned by many authors who have in some instances added new species, it has never been fully defined or described. Nevertheless, there has been general agreement concerning its characteristics. The anterior flaring of the facial sutures and the long, slender, curved palpebral lobes on the cranidium, and the broad thoracic and pygidial axes, and spined posterior margin of the pygidium are distinctive of the genus. Individual cranidia resemble those of *Albertella* Walcott, *Fieldaspis* Rasetti and *Stephenaspis* Rasetti, but complete specimens can be recognized by the multispinose margin of the pygidium.

There is some confusion about the type of this genus. Most workers have cited *Ogygia? spinosa* Walcott as genotype, but *Embolimus spinosa* Rominger from the Stephen formation of British Columbia is the species that should be cited. Walcott (1888, p. 165) proposed *Zacanthoides* to replace *Embolimus* Rominger (1887, p. 15), which was occupied by *Embolemus* Westwood, 1833. The only species of *Embolimus* Rominger that was retained in *Zacanthoides* was *E. spinosa* Rominger,

1877. This species automatically became the genotype of *Zacanthoides*.

Walcott, however, considered *E. spinosa* Rominger a junior synonym of *O.? spinosa* Walcott, 1884, thus making *O.? spinosa* Walcott the name of the genotype species. Resser, 1935, considered Rominger's and Walcott's species to be different and proposed *Z. romingeri* Resser to replace the specific name *spinosa*, which was occupied by that of Walcott's species. The genotype of *Zacanthoides* therefore is *Embolimus spinosa* Rominger (=*Z. romingeri* Resser) the species originally described by Rominger for *Embolimus*, (name replaced by *Zacanthoides* by Walcott).

Zacanthoides spinosus (Walcott)

Plate 15, figures 5, 7

Ogygia? spinosa Walcott, 1884, U. S. Geol. Survey Mon. 8, p. 63, pl. 9, fig. 22.

Olenoides spinosus (Walcott), Walcott [part], 1886, U. S. Geol. Survey Bull. 30, p. 184, pl. 25, fig. 6.

Description.—The cranidium of this species was described in detail by Walcott (1884, p. 63).

Glabella elongate, not quite twice as long as wide; sides parallel nearly to the front, which is slightly expanded and broadly rounded anteriorly; moderately convex and subangular along the median line; marked by three pairs of oblique furrows that extend one-third the distance across; occipital ring strong, not very convex, and with a rather strong central spine projecting backward and upward; occipital furrow shallow, well defined; fixed cheeks narrow; palpebral lobes large, rising slightly from the dorsal furrows to the depressed furrow just within and parallel to their margins; frontal limb convex, of medium width and length, and bordered by a flattened rim. The presence of the strong occipital spine is one of the most distinct characters of this species.

Pygidium subquadrate in outline, somewhat wider than long. Axis well defined, elevated above pleural lobes, parallel sided, bluntly terminated, reaching to border, bearing three distinct axial segments. Pleural lobes flat, three pairs of pleural segments distinguishable. Interpleural grooves broad, shallow. Pleural furrows narrow. Margin with four pairs of short flat spines of nearly equal size and length and a fifth inner pair about half the size of the others.

Discussion.—The cranidium of *Z. spinosus* (Walcott) is similar in nearly all of its observable characters to *Z. typicalis* (Walcott), differing only in the glabella, which is slightly expanded and more bluntly terminated anteriorly. The pygidium, from about the same horizon as the described cranidium, is unique in the character of the marginal spines which are unlike those of any other species of *Zacanthoides*.

Occurrence.—Middle Cambrian, Geddes limestone of Wheeler and Lemmon (1939) Eureka district, Nev.

Figured specimens.—Holotype cranidium, USNM 15451, length (not including spines), 20 millimeters; pygidium, USNM 123352, length (not including spines), 8 millimeters.

Zacanthoides typicalis (Walcott)

Plate 15, figure 9

Olenoides typicalis Walcott, 1886, U. S. Geol. Survey Bull. 30, p. 183, pl. 25, figs. 2, 2a.

Zacanthoides typicalis (Walcott), Pack, 1906, Jour. Geol., v. 14, no. 4, p. 299, pl. 3, figs. 2–2f.

Walcott, 1913, Carnegie Inst. Washington Pub. 54, pl. 24, fig. 2.

Shimer and Shrock, 1944, Index Fossils of North America, p. 619, pl. 257, figs. 20–22.

Description.—This species was described in considerable detail by Walcott (1886, p. 183).

Form ovate. Head large, semicircular in outline. Glabella elongate, not quite twice so long as wide; sides subparallel; front broadly rounded; general surface moderately convex and marked by four pairs of glabellar furrows that extend about one-third the distance across, the anterior being scarcely discernable in most specimens; occipital furrow well defined; occipital ring strong, not very convex, and with a rather strong central spine projecting backwards over the thorax.

Fixed cheeks broad inside the rim of the eye, contracted at the front of the eye and expanding to unite with the frontal limb, which is of medium width, concave, and bordered by a narrow, rim-like margin; postero-lateral limbs narrow, elongate, with a central longitudinal ridge and a rather long spine extending backward just within the extremity of the limb. Free cheeks large, bordered exteriorly by a rather thick rim that is produced into a strong genal spine. Eyes narrow, elongate, reaching from opposite the third pair of glabellar furrows back nearly to the posterior margin, conforming in direction to the eye of *Paradoxides rugulosus*.

Thorax with nine segments; axial lobe convex, broad, and tapering very gradually towards the pygidium; a furrow crosses obliquely from each posterior side of the segment and almost unites before the base of a short spine that originates at the center of each segment and extends upward and backward. The spine on the eighth segment is prolonged and extends back quite a distance beyond the extremity of the terminal spines of the pygidium. An individual 15^{mm} long shows the spine with a length of 10^{mm}. The body of the pleural lobes is narrow, and each pleura is extended in a long spine; pleural groove short and nearly as broad as in the genus Olenellus.

Pygidium subquadrangular; median lobe obconical, convex, divided into three segments and a terminal portion; lateral lobes formed of three segments directed backward, terminating in sharp points and gradually decreasing in size backward.

Discussion.—*Z. typicalis* (Walcott) is characterized by a cranidial border slightly narrower than the brim, by the anterior branch of the facial suture which nearly touches the dorsal furrow immediately in front of the palpebral lobe, by the relatively broad axial lobe of the thorax and pygidium, and by having three pairs of marginal spines decreasing in length posteriorly on the pygidium.

The hypostome described for this species probably belongs to *Alokistocare piochensis* (Walcott), an associated ptychopariid trilobite. It lacks the strong

"anterior wings" cited by Rasetti (1952, p. 890) for corynexochid trilobites.

Occurrence.—Middle Cambrian, Chisholm shale, Pioche, Nev.

Figured specimen.—Holotype, nearly complete carapace, USNM 15454, length, 33 millimeters.

Superfamily PTYCHOPARIOIDEA Richter

Rasetti (1951, p. 198) gives an excellent discussion of the problems facing a paleontologist dealing with trilobites of this superfamily. The genera discussed here are arranged alphabetically.

Genus ALOKISTOCARE Lorenz, 1906

Alokistocare Lorenz, 1906, Deutsche Geol. Gesell. Zeitschr., Band 58, p. 62.
Walcott, 1916, Smithsonian Misc. Coll., v. 64 no. 5, p. 182.
Resser, 1935, idem, v. 93, no. 5, p. 4.
Rasetti, 1951, idem, v. 116, no. 5, p. 202.
Amecephalus Walcott, 1924, idem, v. 75, no. 2, p. 53.
Walcott, 1925, idem, no. 3, p. 65.

Genotype.—Conocephalites subcoronatus Hall and Whitfield, 1877 (p. 237, pl. 2, fig. 1).

Diagnosis.—Micropygous ptychoparioidea. Frontal area long. Brim and border present but poorly differentiated. Median swelling extends from brim onto border. Width of fixed cheeks greater than one-half width of glabella. Thorax of 17 to 23 segments.

Description.—Cephalon subsemicircular in outline; posterior margin straight; distinct genal spines extend posteriorly from posterolateral corners.

Cranidium subquadrate in outline, gently to moderately rounded anteriorly. Glabella well defined by dorsal furrow, tapered forward, bluntly rounded or truncate anteriorly; 3 or 4 pairs of shallow glabellar furrows usually visible. Occipital furrow deep at sides of glabella, shallow across midline. Occipital ring flat. Frontal area long, broad; border flat or gently arched upward or downward; axial length variable. A low, poorly defined median swelling extends from brim onto border. Fixed cheeks, gently to moderately arched; width usually more than half that of glabella; ocular ridges extend from palpebral lobes to dorsal furrow just behind anterior end of glabella. Posterior limbs as long or longer than occipital ring.

Facial sutures divergent forward from palpebral lobes until nearly across border, then turned abruptly inward to cut anterior margin about midway between anterolateral corner of cranidium and longitudinal axis. Posterior suture cuts margin well within genal angle.

Free cheek with evenly curved lateral margin. Border concave, narrower than ocular platform.

Thorax of 17 to 23 segments in known articulated specimens. Axial lobe narrower than pleural lobes, well defined by dorsal furrows. Pleural lobes of each segment with distinct pleural furrows and rounded or pointed distal extremities.

Pygidium with prominent axial lobe reaching nearly to posterior margin; pleural lobes triangular in outline, about as wide as axial lobe at anterior margin. Border concave, poorly defined, narrows posteriorly. Furrows on axial and pleural lobes shallow.

Surface of carapace smooth, granular or pitted.

Discussion.—Lorenz (1906, p. 62) proposed this genus with *C. subcoronatus* as type without giving a diagnosis. The first diagnosis was by Walcott (1916, p. 182). Resser (1935, p. 4) redefined the genus to exclude some of the species placed in it by Walcott. He also concluded that *Amecephalus* Walcott (1924, p. 53) was a synonym of *Alokistocare*. Rasetti (1951, p. 202) discussed *Alokistocare* and considered *Amecephalus* as a recognizable genus. The writer considers the evidence given below to be sufficient for placing *Amecephalus* Walcott, 1924, in the synonymy with *Alokistocare* Lorenz, 1906.

The genotype of *Alokistocare* is represented only by cranidia preserved in dark limestone. The genotype of *Amecephalus* is represented by flattened complete and disarticulated specimens in a soft, brown shale. Four species of *Alokistocare* were described by Resser (1938) from complete trilobite shields in the Spence shale of Idaho. Comparison of the cranidia with those assigned to *A. subcoronatum* (Hall and Whitfield) indicates that the generic determination for the specimens described by Resser is probably correct. Furthermore, the specimens from Idaho and *A. subcoronatum* (Hall and Whitfield) from northern Utah come from about the same stratigraphic horizon. Rasetti (1951, p. 202) states "If forms known from complete shields and described by Resser as *Alokistocare* belong to the genus, they appear to differ from *Amecephalus piochensis* in possessing somewhat narrower fixed cheeks and in the different form of the thoracic pleura, which extend into falcate terminations in *Amecephalus piochensis*, while they remain almost straight in the forms assigned to *Alokistocare*." He considers these differences of generic importance.

The writer has examined the complete shields mentioned by Rasetti and assigned to four species of *Alokistocare* by Resser. Two of the species, *A. idahoense* Resser and *A. spencense* Resser, have falcate thoracic terminations similar to those of *Amecephalus piochensis* (Walcott). The other two species, *A. laticeps* Resser and *A. septum* Resser, have rounded thoracic terminations with one exception—a specimen of *A. septum* Resser with the large long, genal spines and granular surface characteristic of that species but with falcate thoracic terminations. It seems un-

likely, then, that the character of the thoracic terminations is of generic importance in the *Alokistocare-Amecephalus* group of trilobites.

The width of the fixed cheeks, including the palpebral lobes, divided by the width of the glabella on the same transverse line gives figures of: 1.19, 1.15 and 1.15 for 3 limestone specimens selected at random from a collection of *Alokistocare subcoronatum* (Hall and Whitfield); 1.00, 1.13 and 1.15 for 3 slightly crushed shale specimens selected at random from a collection of *Alokistocare idahoense* Resser; and 1.00, 1.19 and 1.18 for 3 flattened shale specimens selected at random from a collection of *Amecephalus piochensis* (Walcott). These ratios suggest that differences in the relative width of the fixed cheeks of these trilobites, like the differences in thoracic terminations, are not valid criteria for generic differentiation.

Alokistocare piochensis (Walcott)

Plate 16, figures 1, 2, 5

Ptychoparia piochensis Walcott, 1886, U. S. Geol. Survey Bull. 30, p. 201, pl. 26, fig. 2b; pl. 28, figs. 1, 1a–e.
Pack, 1906, Jour. Geol. v. 14, no. 4, p. 297, pl. 2, fig. 4a.
Amecephalus piochensis (Walcott), 1924, Smithsonian Misc. Coll., v. 75, no. 2, p. 53, pl. 9, fig. 1.
Walcott, 1925, idem, no. 3, p. 66, pl. 15, figs. 8–10.
Alokistocare packi Resser, 1935, idem, v. 93, no. 5, p. 9.

Description.—Walcott (1886, p. 201) gives a detailed description of this species as follows:

General form ovate, moderately convex, usually much depressed by being flattened in the shaly matrix.

Head transverse, semicircular; frontal margin comparatively narrow in young individuals, becoming broader and more flattened with the increase in size of the animal; postero-lateral angles prolonged into slender spines. Glabella of medium size, truncatoconical, and marked with three pairs of short glabellar furrows that increase in size and also in obliquity to the central axis on the larger heads; occipital groove shallow and rounded downward from the base of the glabella and upward to the moderately strong occipital ring; a small point or node occurs at the center of the latter. Fixed cheeks of medium width; they merge in front into the broad frontal limb and posteriorly into the elongate, narrow, postero-lateral limbs; palpebral lobes small; ocular ridges well defined and terminating nearly at the front of the glabella; frontal limb comparatively narrow in the young and broader in the older and larger specimens.

Thorax with 19 segments in two specimens 30^{mm} and 40^{mm} long, respectively; another specimen, 18^{mm} long, shows 17 segments; the segments are nearly transverse, except at the geniculation on the pleural lobes, where the falcate extremities bend slightly backward; axial lobe moderately convex; pleural lobes flattened half-way out and then curved downward to their margin; pleural groove of medium width and continued well out towards the extremity of the segment.

Pygidium small, semicircular; axial lobe with 3 or 4 segments; lateral lobes small and marked by furrows indicating about 3 united segments.

Discussion.—*A. piochensis* (Walcott) is characterized by having the midlength of the border of the cranidium less than the midlength of the brim, 17 to 19 thoracic segments, and a small pygidium.

Resser (1935, p. 9) placed two specimens figured by Walcott (1886, pl. 28, figs. 1c, 1d) as *Ptychoparia piochensis* in a new species, *Alokistocare packi* with the following comment: "In the narrowness of the cranidium this species is like *A. pomona.*" This is hardly an adequate specific diagnosis. The specimens, both small, are associated with *Alokistocare piochensis* (Walcott). Walcott's interpretation of them as small individuals of that species is more probably correct.

Occurrence.—Middle Cambrian, Chisholm shale, Pioche, Nev.

Figured specimens.—Holotype cranidium, USNM 15434, length, 25 millimeters; nearly complete carapace, USNM 15434, length, 28 millimeters; small, nearly complete carapace, USNM 15434, length, 17 millimeters.

Alokistocare subcoronatum (Hall and Whitfield)

Plate 15, figure 8

Concephalites subcoronatus Hall and Whitfield, 1877, U. S. Geol. Expl. 40th Par. Rept., v. 4, p. 237, pl. 2, fig. 1.
Ptychoparia subcoronata (Hall and Whitfield), Walcott, 1886, U. S. Geol. Survey Bull. 30, p. 205, pl. 28, fig. 4.
Walcott, 1890, U. S. Geol. Survey 10th Ann. Rept., pt. 1, p. 652, pl. 96, fig. 6.
Alokistocare subcoronatum (Hall and Whitfield), Walcott, 1916, Smithsonian Misc. Coll., v. 64, no. 5, p. 187, pl. 25, fig. 2.

Description.—This species was described in considerable detail by Hall and Whitfield (1877, p. 237).

Glabella short, conical, with straight lateral margins, regularly converging from the base upward to the rather squarely truncated summit; height above the occipital furrow scarcely exceeding the breadth of the base, and the width at the summit equal to about two-thirds of the height; marked by three pairs of very oblique, subequally distant, and moderately distinct transverse furrows. Occipital furrow narrow and well marked; ring distinct, widest and somewhat pointed on the center of the posterior margin.

Fixed cheeks wide, separated from the glabella by distinct dorsal furrows, prominent and rounded between the glabella and eye-lobe, almost equaling the convexity of the glabella; ocular ridges slender and curved. Frontal limb wide and concave, destitute of a thickened marginal rim, as long as the glabella, and obscurely trilobed from an extension of the dorsal furrows, forming a convex, boss-like area in front of the glabella, which is divided transversely by a double depressed line, or narrow fillet, midway of the limb and parallel with the anterior margin of the head. Eye-lobes about half as long as the glabella, obliquely situated, and separated from the fixed cheek by a deeply-depressed ocular sinus.

Facial suture cutting the anterior border on a line with the front angle of the eye, which it reaches by a broad, convex curvature, giving rounded lateral margins to the frontal limb; posterior to the eye, it is directed outward; the actual course not determined. Posterior lateral limbs not seen. Surface of the crust in front of the glabella strongly striated.

Discussion.—Although there is no "thickened marginal rim" on the cranidium as noted by Hall and

Whitfield, there is a concave border nearly twice the length of the brim. It is defined by a shallow marginal furrow that parallels the eye lines and the front of the glabella and crosses the low faint median boss. The character of the marginal furrow, relative proportions of the brim to border, low median boss, distinct occipital furrow, and relatively small size are characteristic of the species.

Occurrence.—Middle Cambrian, Ute limestone, Bear River Range, Utah.

Figured specimen.—Holotype cranidium, USNM 15442, length, 5 millimeters.

Genus ASAPHISCUS Meek, 1873

Asaphiscus Meek, 1873, U. S. Geol. Survey Terr. 6th Ann. Rept., p. 485.
Walcott, 1886, U. S. Geol. Survey Bull. 30, p. 219.
Resser, 1935, Smithsonian Misc. Coll., v. 93, no. 5, p. 12.
Eteraspis Resser, 1935, idem, p. 28.

Genotype.—*Asaphiscus wheeleri* Meek, 1873 (p. 485).

Diagnosis.—Cephalon subsemicircular in outline, posterior margin nearly straight, genal angles rounded.

Cranidium with glabella tapered forward, strongly rounded anteriorly, poorly defined by shallow dorsal furrow. Glabellar furrows not visible. Occipital furrow shallow. Occipital ring gently rounded. Frontal area with deep, curved marginal furrow. Border gently arched upward, width constant. Fixed cheeks downsloping from glabella; palpebral lobes not defined by palpebral furrow, situated opposite middle third of glabella. Length of posterior limbs about equal to width of glabella at occipital furrow; marginal furrow broad, shallow. Facial sutures divergent anterior and posterior to palpebral lobes. Anterior course extended onto border and then turned abruptly inward to cut anterior margin intermediate between anterolateral corners of cranidium and longitudinal axis. Posterior course extended backward and outward in even curve to cut margin within genal angle.

Free cheek with evenly rounded lateral margin. Marginal furrow moderately deep, parallels margin. Genal angle rounded.

Thorax consists of nine segments. Axial lobe prominent, narrower than pleural lobes. Pleural lobes of each segment subequally divided by deep pleural furrows near axial lobe, flattened and rounded distally.

Pygidium about as large as cephalon, subsemicircular in outline, width less than twice length. Axial lobe prominent, tapered posteriorly, extended to or onto border. Border of nearly constant width, narrower than widest portion of pleural platform. Axial and pleural furrows shallow.

Discussion.—The deep marginal furrow, shallow dorsal furrow, and rounded genal angles of the cephalon of this genus are its most distinctive characteristics.

Walcott (1916, p. 383) expanded the genus to include 13 species from Middle and Upper Cambrian rocks of North America and Asia. Resser (1935, p. 12) restricted it to *A. wheeleri* Meek and *A. iddingsi* Walcott, and all other species assigned to the genus up to that time were placed elsewhere. Resser and Endo (1937, p. 180–183) described 6 new Asiatic species of *Asaphiscus* similar to *A. iddingsi* Walcott. The Asiatic trilobites differ from the genotype by their well defined glabellas, relatively longer palpebral lobes, and genal spines. The writer does not consider them to belong to the genus.

Resser (1935, p. 28) proposed the genus *Eteraspis* with *Ptychoparia laeviceps* Walcott as genotype. Although the free cheeks of *P. laeviceps* Walcott are not known, the writer considers the species congeneric with *Asaphicus wheeleri* Meek. (See discussion of *A. laeviceps* (Walcott).) *Eteraspis* Resser, 1935, becomes therefore a synonym of *Asaphiscus* Meek, 1873.

Asaphiscus laeviceps (Walcott)

Plate 16, figures 4, 6

Ptychoparia laeviceps Walcott, 1884, U. S. Geol. Survey Mon 8, p. 54, pl. 10, fig. 17.
Eteraspis laeviceps (Walcott), Resser, 1935, Smithsonian Misc. Coll., v. 93, no. 5, p. 28.
Shimer and Shrock, 1944, Index Fossils of North America, p. 611, pl. 255, fig. 20.

Description.—Walcott (1884, p. 54) presented a detailed description of the cranidium of this species.

General form of head within the facial sutures subtrapezoidal. Glabella conical, strongly convex, with very faintly defined dorsal furrows separating it from the rapidly sloping fixed cheeks; two pairs of furrows are just discernible by slight impressions on the surface; occipital ring strong, rounded, separated from the glabella by a shallow furrow; fixed cheeks of medium width, sloping rapidly down from the glabella and from the small eyelobe, situated a little back of the center, to the front and back; frontal limb short, convex, and depressed to the broadly rounded, strong, marginal rim; postero-lateral limbs rather strong and running out beyond the line of the lateral extension of the frontal limb.

Pygidium subsemicircular in outline; width slightly less than twice length. Axial lobe elongate, distinctly elevated above pleural platforms, tapering posteriorly, merging with border. Border faintly defined by marginal furrow, maintaining nearly constant width. Axis and pleural lobes marked by several extremely faint furrows.

Discussion.—*Ptychoparia laeviceps* Walcott was made the type of *Eteraspis* by Resser (1935, p. 28). He did not compare the genus to any already described. Examination of the specimens of *P. laeviceps* Walcott and *Asaphiscus wheeleri* Meek suggests that they represent two species of a single genus. The cranidia are nearly identical. The pygidium of *P. laeviceps* Walcott differs from that of *A. wheeleri* Meek by having the axial lobe

extended onto and merged with the border and the border convex instead of concave. The writer does not feel that the differences between the species are of generic importance and considers *Eteraspis* Resser a synonym of *Asaphiscus* Meek.

A. laeviceps (Walcott) is younger than *A. wheeleri* Meek and occurs at or near the top of the Middle Cambrian.

Occurrence.—Middle Cambrian, Hamburg limestone (lower part), Eureka, Nev.

Figured specimens.—Holotype cranidium, USNM 24614, length, 7.5 millimeters; pygidium, USNM 24614, length 5 millimeters.

Asaphiscus wheeleri Meek

Plate 16, figure 7

Asaphiscus wheeleri Meek, 1873, U. S. Geol. Survey Terr. 6th Ann. Rept., p. 485.
White, 1877, U. S. Geog. Surveys W. 100th Mer., v. 4, p. 43, pl. 2, figs. 1a–f.
Walcott, 1886, U. S. Geol. Survey Bull. 30, p. 220, pl. 25, fig. 9; pl. 31, figs. 3, 3a.
Walcott, 1916, Smithsonian Misc. Coll., v. 64, no. 5, p. 390, pl. 58, figs. 1a–g.
Shimer and Shrock, 1944, Index Fossils of North America, p. 607, pl. 258, fig. 9.

Description.—White (1877, p. 43) presented a detailed description of this species.

Body oblong-ovate in outline; surface smooth. Head depressed convex; front margin regularly rounded; posterolateral angles abruptly rounded, without cheek spines; exterior margin bent shortly upward all around, producing a raised border of considerable width, and also a rather deep linear depression, or groove, parallel with that border and between it and the remainder of the cheeks. Glabella conical, much wider behind than in front, depressed; space between its anterior end and the marginal groove about equal to the width of the raised marginal rim in front of it; outline well defined by the narrow dorsal furrows; sides nearly straight; anterior end abruptly and posterior end broadly rounded, without lateral furrows, or at least they are hardly discernible; occipital furrow shallow, broad, but somewhat distinct and uniform, extending entirely across the glabella, and continuous with furrows similar to itself that extend to the posterolateral angles of the head; the latter furrows lie parallel with and near to the posterior margin of the head, giving that margin also a raised border, somewhat like the one upon the exterior margin. Eyes comparatively small, crescentic, situated nearly opposite the mid-length of the glabella, and nearly equidistant from it and the posterior margin.

Thorax having nine segments; its length not quite so great as that of the head; axis broadest anteriorly, more strongly convex, and about one-third narrower than the lateral lobes are; segments extending straight across the lobe; lateral lobes depressed, their greatest convexity along the middle; pleurae bluntly pointed at their outer ends, the points not being directed very strongly backward; their inner ends so joined to the axial segments that they have the appearance of lapping a little upon them just inside the dorsal furrow; grooved, the groove being deepest about mid-length, where the outer and inner portions of its front border meet at a distinct but very obtuse angle; grooves extending from the dorsal furrow nearly to the extremity of the pleurae, where they disappear.

Pygidium somewhat semicircular in outline, distinct trilobate; segmentation indistinct, so much so in some of the specimens that the surface appears nearly as plain as that of an *Asaphus*, but the segmentation is usually more distinctly shown upon surfaces from which the crust has been removed; axis prominent, especially at its distal end, where it terminates abruptly at the inner edge of the broad marginal border; segments of axial lobe eight or ten; lateral lobes much depressed, a little wider than the axial lobe at the anterior end, and narrowing to an incurved point at the end of the axis; the whole exterior margin having a broad, flat border of nearly uniform width throughout; the under surface of this border marked by fine, somewhat irregular, longitudinal striae, such as are usually seen upon corresponding parts of *Asaphus*.

The largest specimen in the collection is about seven centimeters long.

Discussion.—This species is characterized by the subequal axial lengths of the brim and border on the cranidium and by the axial lobe of the pygidium, which reaches to, but not onto, the border.

The types of this species are all fragmentary. The specimen pictured here, although slightly crushed, is the best specimen in the U. S. National Museum collections and is from topotype material. It exhibits all of the distinctive characters of the species. *A. laeviceps* (Walcott) (pl. 16, fig. 4) from the Eureka district, Nev. shows the natural convexity of cranidia of this genus.

Occurrence.—Middle Cambrian, Wheeler formation, House Range, Utah.

Figured specimen. — Complete carapace, USNM 15460, length, 28 millimeters.

Genus BOLASPIDELLA Resser, 1937

Bolaspidella Resser, 1937, Smithsonian Misc. Coll., v. 95, no. 22, p. 3.
Shaw, 1952, Jour. Paleontology v. 26, no. 3, p. 477.
Palmer, 1954, [in press] Jour. Paleontology.
Hysteropleura Raymond, 1937, Geol. Soc. America Bull., v. 48, no. 8, p. 1094.
Deltophthalamus Resser, 1938a, Geol. Soc. America Special Paper 15, p. 74.
Deissella Howell and Duncan, 1939, Wagner Free Inst. Sci. Bull., v. 14, no. 1, p. 7.
Shimer and Shrock, 1944, Index Fossils of North America, p. 609.
Howellaspis Lochman and Denson, 1944, *in* Lochman and Duncan, 1944, Geol. Soc. America Special Paper 54, p. 125.

Genotype.—*Ptychoparia housensis* Walcott, 1886 (p. 201, pl. 25, fig. 5).

Diagnosis.—Small micropygous trilobites. Cranidium with prominent subquadrate glabella; glabellar furrows represented by pits on sides of glabella. Occipital furrow deep. Occipital ring with or without spine. Frontal area concave. Brim and border distinct; border usually upturned. Width of fixed cheeks greater than one-half width of glabella; palpebral lobes small,

opposite or anterior to middle third of glabella. Ocular ridges usually present. Facial sutures directed straight forward in front of palpebral lobes; widely divergent behind.

Free cheek transversely elongate with evenly rounded margin, short genal spine.

Thorax consists of 15 segments. Axial lobe narrower than pleural lobes. Distal extremities of each segment sharply rounded.

Pygidium with prominent conical axial lobe reaching nearly to posterior margin. Axial and pleural lobes with 2 or 3 shallow furrows.

Discussion.—This genus is common in rocks of late Middle Cambrian and earliest Late Cambrian age. It has been found in the Cordilleran and Appalachian regions and central Texas. The prominent subquadrate glabella, concave frontal area, and wide fixed cheeks are particularly characteristic of the cranidium. A complete specimen collected by the writer from the Wheeler formation at the *Elrathia kingii* type locality, and the genotype of *Deltophthalamus* Resser, provided information about the free cheeks, thorax and pygidium. Disassociated free cheeks and a pygidium have been described from central Texas (Palmer, 1954, in press).

Hysteropleura, *Deissella* and *Howellaspis* were considered synonyms of *Bolaspidella* by Shaw (1952, p. 477). *Deltophthalamus* has been considered a synonym of *Bolaspidella* by the writer (Palmer, 1954, in press).

Bolaspidella housensis (Walcott)

Plate 16, figure 3

Ptychoparia housensis Walcott, 1886, U. S. Geol. Survey Bull. 30, p. 201, pl. 25, fig 5.

Description.—The cranidium and only known part of this species was described by Walcott (1886, p. 201).

Head small, transversely quadrilateral exclusive of the free cheeks; moderately convex. Glabella rather small, of almost uniform width from the posterior margin to the rounded front; furrows shown only by a posterior pair; occipital ring strong and bearing a short small spine that extends obliquely upward and backward; occipital furrow of moderate depth and continued out as a strong groove on the lateral limbs; dorsal furrows broad and well defined. Fixed cheeks wider than the glabella; palpebral lobes small; ocular ridges strongly defined; frontal limb concave, of medium width, and rising to a strong frontal rim; postero-lateral limbs short. Surface finely granulose.

Discussion.—*P. housensis* (Walcott) differs from all other species of *Bolaspidella* by possessing an occipital spine.

Occurrence.—Middle Cambrian, Wheeler formation, House Range, Utah.

Figured specimen.—Holotype cranidium, USNM 24614, length 4 millimeters.

Genus EHMANIELLA Resser, 1937

Ehmaniella Resser, 1937, Smithsonian Misc. Coll., v. 95, no. 22, p. 10.

Genotype.—*Crepicephalus* (*Loganellus*) *quadrans* Hall and Whitfield, 1877 (p. 238, pl. 2, figs. 11–13).

Diagnosis.—Cranidium with anterior margin gently and evenly rounded, glabella prominent, tapered forward, bluntly rounded anteriorly; dorsal furrow deep at sides, shallow across front. Four pairs of glabellar furrows visible on well-preserved specimens. Occipital furrow deep at sides, shallow on midline. Occipital ring with or without spine. Frontal area with distinct brim and border separated by shallow marginal furrow or by sudden change in slope; border maintains constant width; axial length of frontal area less than half that of glabella. Width of fixed cheeks about one-half that of glabella. Prominent ocular ridges present. These touch dorsal furrow opposite anterior pair of glabellar furrows. Palpebral lobes poorly defined by shallow palpebral furrow, depressed below general level of cheeks, opposite middle third of glabella. Length of posterior limbs about equal to width of glabella at occipital furrow. Anterior and posterior courses of facial sutures divergent from palpebral lobes; anterior course intramarginal on border nearly to axial line.

Free cheek with margin evenly rounded. Border narrower than ocular platform, well defined by shallow marginal furrow, extended into short, pointed genal spine.

Thorax of 13 segments. Axial lobe prominent, narrower than pleural lobes. Distal ends of pleural lobes of each segment rounded or extended into short sharp spines.

Pygidium with axial length one-half or more width. Axial lobe tapered posteriorly, not extended to posterior margin, composed of 3 to 5 segments. Pleural lobes with 2 or more pairs of pleural furrows and interpleural grooves of about equal strength; each pair of furrows directed more posteriorly than preceding pair. Border not present, but distal margins of downsloping pleural lobes flexed outward.

Surface of carapace smooth.

Discussion.—The choice of genotype for this genus was unfortunate. The types of *E. quadrans* (Hall and Whitfield) are flattened and the diagnostic generic characteristics are distorted or poorly preserved. Specimens from USGS locality 20x (OS), limestones in the Spence shale from near the type area, are undisdistorted and show the generic characteristics. The character of the thorax was taken from specimens described by Rasetti (1951, p. 218, 219) from the Stephen formation in British Columbia.

The genus differs from *Ehmania* Resser only in characters of the cranidium. The ocular ridges are

more prominent; the axial length of the border is less than that of the brim, and the border is not tapered distally. The cranidium differs from those of other similar genera by having an anteriorly tapered glabella, a shallow or indistinct marginal furrow, anteriorly divergent facial sutures, and the palpebral lobes opposite the middle third of the glabella. The greater relative length, more distinctly furrowed pleural lobes and lack of a well-defined border distinguish the pygidium from those of similar genera.

Ehmaniella quadrans (Hall and Whitfield)

Plate 17, figures 1–5

Crepicephalus? (*Loganellus*) *quadrans* Hall and Whitfield, 1877, U. S. Geol. Expl. 40th Par. Rept. v. 4, p. 238, pl. 2, figs. 11–13.

Ptychoparia quadrans (Hall and Whitfield), Walcott, 1886, U. S. Geol. Survey Bull. 30, p. 199, pl. 29, figs. 4, 4a, b.

Ehmaniella quadrans (Hall and Whitfield), Resser, 1939, Smithsonian Misc. Coll., v. 97, no. 12, p. 19, pl. 6, figs. 28–32.

Description.—This species was described in detail by Hall and Whitfield (1877, p. 238).

Form of entire body unknown. Glabella and fixed cheeks together broadly quadrangular, about four-fifths as high as wide and quite uniform in many individuals, very depressed-convex or quite flattened, as occurring on the surface of the shale in which they are imbedded; glabella distinctly conical, moderately tapering above the occipital furrow, and broadly rounded in front; marked by three pairs of distinct transverse furrows, which are directed obliquely backward from their outer ends; the posterior pair almost or quite meeting in the middle, the others shorter and situated at almost equal distances from each other. Occipital furrow well marked, proportionally wide and shallow; occipital ring narrow, not well defined.

Fixed cheeks very broad, nearly two-thirds as wide as the glabella, depressed-convex; frontal limb short, the broader and inner part of nearly the same width; sides of the limb in front, wide, and slightly rounded at the antero-lateral angles; posterior limb wide at its junction with the glabella, and rapidly narrowing outward, being about once and a half as long as its greatest width; ocular ridges slender, but very distinct, rising from the anterior angle of the eye and uniting with the glabella near the anterior furrow, forming a slightly curved line parallel with the marginal furrow of the head.

Facial sutures directed inward from the anterior margin of the head to the eye-lobe, behind which they are directed outward and backward to the posterior margin of the head, at an angle of about forty degrees to the occipital line.

A form of movable cheek found associated in considerable numbers with the glabellas, and corresponding in size and character, is narrowly triangular, the posterior extremity terminating in a short, blunt spine, slightly curved; inner angle strongly notched for the reception of the eye-lobe, and the outer margin bordered by a thickened, rounded rim, which gradually increases in width to the base of the spine. The facial suture corresponds to the margin of the fixed cheek above described, and, on the under side, the anterior border is prolonged in the form of an acute process, to extend along the anterior border of the frontal limb.

The pygidium associated with the above specimens is minute, transversely subelliptical in form, most strongly rounded on the front border, with a wide axis terminating obtusely a little within the posterior margin. The axis is marked by five rings, exclusive of the terminal ones. Lateral lobes convex, marked by three or four divided ribs, exclusive of the anterior single one.

Surface of the head and cheeks marked by fine anastomosing lines, radiating from the eye and front of the glabella.

Discussion.—This species is similar to *Ehmania weedi* Resser, the genotype of *Ehmania*. The cranidium has a shorter border that is not tapered distally and more prominent ocular ridges. The pygidium has each successive pair of pleural furrows and interpleural grooves more strongly curved posteriorly. On the pygidium of *Ehmania*, the furrows and grooves maintain a nearly constant angle with the axial line.

Occurrence.—Middle Cambrian, Spence shale member of the Ute limestone, Wasatch Range, Utah.

Figured specimens.—Holotype cranidium, USNM 15432, length, 5.5 millimeters; pygidium, USNM 15432, length, 3.5 millimeters; crandium, USNM 123351a, length, 6 millimeters; pygidium USNM 123351b, length, 4 millimeters; free cheek, USNM 15432, width 3.5 millimeters.

Genus ELDORADIA Resser, 1935

Eldoradia Resser, 1935, Smithsonian Misc. Coll., v. 93, no. 5, p. 26.

Genotype.—Ptychoparia? linnarssoni Walcott, 1884 (p. 47, pl. 9, figs. 18, 18a).

Diagnosis.—Cranidium subquadrate in outline; glabella prominent, relatively small, tapered forward, truncate anteriorly. Glabellar furrows shallow or absent. Occipital furrow shallow. Frontal area nearly as long as glabella; border not distinctly differentiated from brim; brim with large median boss extending from front of glabella to border. Fixed cheeks as wide or wider than glabella. Palpebral lobes small, opposite anterior third of glabella; palpebral furrow absent. Facial sutures straight forward in front of palpebral lobes, widely divergent behind.

Free cheek, thorax, and pygidium unknown.

Discussion.—This genus is distinguished from *Alokistocare* by the confinement of the preglabellar median boss to the brim and the continuation of the shallow marginal furrow around the front of the boss instead of over it.

The writer has seen specimens of *Eldoradia* from an undetermined formation in the House Range in Utah and from the Abrigo limestone in the Tombstone and Bisbee mining districts in southeastern Arizona, in addition to those from the Eureka mining district in Nevada.

Eldoradia dunbari Lochman (1938, p. 465) from the March Point formation, Newfoundland, lacks a preglabellar median boss and has a short frontal area, distinct glabellar furrows, and the palpebral lobes are

situated opposite the middle third of the glabella. The writer does not consider it as a representative of *Eldoradia*.

Eldoradia linnarssoni (Walcott)

Plate 16, figures 9, 10

Ptychoparia? linnarssoni Walcott, 1884, U. S. Geol. Survey Mon. 8, p. 47, pl. 9, figs. 18, 18a.
Alokistocare linnarssoni (Walcott), Walcott, 1916, Smithsonian Misc. Coll., v. 64, no. 5, p. 185, pl. 25, figs. 7, 7a.
Eldoradia linnarssoni (Walcott), Resser, 1935, idem, v. 93, no. 5, p. 27.
Eldoradia lata Resser, 1935, idem, p. 27.

Description.—Walcott (1889, p. 47) presented a detailed description of the cranidium of this species.

The glabella and fixed cheeks are the only portions of this interesting species that have been identified. The glabella is small in proportion to the area occupied by the cheeks and frontal limb; it is conical in form, truncate in front, moderately convex, and marked by three pairs of very short, slightly impressed glabellar furrows; the latter only observed on very perfect specimens; occipital ring narrow, as also the shallow occipital furrow; fixed cheeks broad, elevated, and projecting forward on to the frontal limb considerably in advance of the front of the glabella, the included space between their anterior portions being occupied by an elongate oval boss that is separated from the glabella by a rather broad, shallow furrow; the boss or tubercle extends to the rounded thick frontal rim, from which it is defined by a scarcely perceptible depression; dorsal furrows broad, well defined, and running out in front much broader between the tubercle and the fixed cheeks; palpebral lobes rather prominent and situated opposite the anterior end of the glabella; postero-lateral limbs long, triangular, and marked by a strong furrow within their posterior margin. Facial suture directed forward in front of the eyelobes, curving outward a trifle and then a little inward on the frontal limb, around the front of which it does not appear to extend; back of the eyelobe it extends obliquely outward and backward, bending a little more abruptly backward towards the lateral extension of the limb, terminating at or just within the genal angle at a distance from the dorsal furrow equal in one example to the length, and in another to two-thirds of the length of the head.

Discussion.—*E. linnarssoni* (Walcott) is characterized by having a short border and the width of the cranidium between the palpebral lobes slightly greater than the length. Resser (1935, p. 27) proposed the name *Eldoradia lata* for one of the specimens of *E. linnarssoni* (Walcott) illustrated by Walcott (1884, 1916). The type of *E. lata* Resser is a weathered cranidium lacking the border. The loss has accentuated the apparent width of the fixed cheeks, which are relatively no wider than those of *E. linnarssoni* (Walcott). The diagnostic specific characteristic of "wider fixed cheeks" seems to be an optical illusion. *E. lata* (Resser) is here considered a synonym of *E. linnarssoni* (Walcott).

Occurrence.—Middle Cambrian, Secret Canyon shale, Eureka, Nev.

Figured specimens.—Holotype cranidium, USNM 24611, length, 8.5 millimeters; cranidium, USNM 90669, length, 8.5 millimeters.

Eldoradia prospectensis (Walcott)

Plate 16, figure 8

Ptychoparia? prospectensis Walcott, 1884, U. S. Geol. Survey Mon. 8, p. 46, pl. 9, fig. 20.
Alokistocare prospectense (Walcott), Walcott, 1916, Smithsonian Misc. coll., v. 64, no. 5, p. 186, pl. 25, fig. 8.

Description.—This species was described in detail by Walcott (1884, p. 46).

The general outline of the head is moderately convex, semicircular, the width being about twice the length.

The glabella is subconical, truncate in front and marked by three pairs of short, slightly impressed glabellar furrows; occipital ring distinctly defined by a narrow, lightly impressed occipital furrow; fixed cheeks broad, of equal elevation with the glabella, and extending beyond it anteriorly, the space between them on the broad frontal limb being taken by a small swelling or boss that, but for the slight transverse dorsal furrow between it and the glabella, might be mistaken for a continuation of the latter; the eyelobes are comparatively large for a species of this character and occupy a prominent position on the outer margin of the cheeks, a distinct ocular ridge crossing the latter from the anterior margin of the eyes to the dorsal furrow on a line with the front of the glabella; the lateral limbs are narrow, rather short, and slope rapidly downward back of the eyelobes; frontal limb broad at the center, narrowing in front of the fixed cheeks and bordered anteriorly by a not very distinctly defined rounded margin. The facial suture curves a little inward in front of the eye and appears to terminate on the front line somewhat in advance of a line passing through the center of the tubercle in front of the glabella; behind the eye it extends obliquely outward and backward to the posterior margin of the head, outlining an elongate triangular postero-lateral limb.

Discussion.—A short border and a cranidium that is wider between the palpebral lobes than it is long characterize *E. prospectensis*. The species is smaller and relatively broader than *E. linnarssoni* (Walcott). Specimens intermediate in size between the types of the two species, however, are also intermediate in the "diagnostic" characters. It is possible that the two merely represent large and small members of the same species. It is also possible that this is an evolutionary difference having a certain amount of stratigraphic importance. The necessary detailed stratigraphic information that would support one or the other of these views is lacking. The writer prefers, therefore, to recognize *E. prospectensis* (Walcott) and *E. linnarssoni* (Walcott) as separate species in the absence of well-documented information to the contrary.

Occurrence.—Middle Cambrian, Secret Canyon shale (?), Eureka, Nev.

Figured specimen.—Holotype cranidium, USNM 15441, length, 4.5 millimeters.

Genus ELRATHIA Walcott, 1924

Elrathia Walcott, 1924, Smithsonian Misc. Coll., v. 75, no. 2, p. 56.

Walcott, 1925, idem, no. 3, p. 86.
Resser, 1935, idem, v. 93, no. 5, p. 27.
Howell, 1937, Geol. Soc. America Bull., v. 48, no. 8, p. 1184.
Shimer and Shrock, 1944, Index Fossils of North America, p. 611.

Genotype.—*Conocoryphe (Conocephalites) kingii* Meek, 1870 (p. 63).

Diagnosis.—Carapace elongate subovate in outline, widest at posterior margin of cephalon.

Cephalon subsemicircular in outline, genal angles extended into genal spines.

Cranidium with anterior margin gently and evenly rounded. Glabella well defined by shallow dorsal furrow, straight sided, tapered forward, strongly and evenly rounded anteriorly. Glabellar furrows shallow or absent. Occipital furrow deepest at sides, shallow on midline. Occipital ring flat or gently arched, unspined. Frontal area with distinct brim and border; border flat or gently arched upward; marginal furrow shallow. Width of fixed cheeks one-half or more width of glabella. Palpebral lobes opposite middle third of glabella, well defined by shallow palpebral furrow. Ocular ridges indistinct. Length of posterior limbs about equal to width of glabella at occipital furrow. Marginal furrow broad, shallow. Facial sutures divergent anterior and posterior to palpebral lobe; anterior course turns inward after reaching border and cuts margin about midway between anterolateral corners of cranidium and axial line; posterior course cuts margin before reaching genal spine.

Free cheek with evenly curved lateral margin. Border well defined by shallow marginal furrow; extended into short genal spine.

Thorax of 13 segments. Axial lobe prominent; width less than half that of pleural lobes. Pleural lobe of each segment subequally divided by deep pleural furrow; distal extremity extended into short, sharp point.

Pygidium subsemicircular in outline, smaller than cephalon; axial length less than one-half width. Axial lobe prominent, not reaching posterior margin; width about one-half that of pleural lobes. Narrow border present, poorly defined by shallow marginal furrow. Furrows on axial and pleural lobes shallow.

Surface of carapace smooth.

Discussion.—The cranidium of this genus can be distinguished from cranidia of similar genera by the unfurrowed, straight-sided glabella with the strongly and evenly rounded anterior end and by the lack of distinct ocular ridges. It may reach a length of 15 millimeters or more. The pygidium is distinguished by its subsemicircular outline, narrow axial lobe, shallow axial and pleural furrows, and by the presence of a distinct border.

Elrathia kingii (Meek)

Plate 17, figure 13

Conocoryphe (Conocephalites) kingii Meek, 1870, Acad. Nat. Sci. Philadelphia Proc., p. 63.
Conocoryphe (Ptychoparia) kingii (Meek). Meek, 1877, U. S. Geol. Expl. 40th Par. Rept., v. 4, p. 20, pl. 1, fig. 4.
White, 1877, U. S. Geog. and Geol. Surveys W. 100th Mer., v. 4, pt. 1, p. 40, pl. 2, figs. 2a–c.
Ptychoparia kingii (Meek). Walcott, 1886, U. S. Geol. Survey Bull. 30, p. 193, pl. 27, figs. 4, 4a.
Walcott, 1913, Carnegie Inst. Washington Pub. 54, v. 3, pl. 12, fig. 6.
Elrathia kingii (Meek). Walcott, 1924, Smithsonian Misc. Coll., v. 75, no. 2, p. 56, pl. 11, fig. 4.
Walcott, 1925, idem, no. 3, p. 87, pl. 15, figs. 1–4.
Shimer and Shrock, 1944, Index Fossils of North America, p. 611, pl. 255, figs. 5, 6.

Description.—Meek (1870, p. 63) described this species in considerable detail.

Entire form ovate and much depressed, with breadth equaling about two-thirds the whole length. Cephalic shield semicircular, or a little wider than long, with the anterior and antero-lateral borders regularly rounded in outline and provided with a narrow, slightly defined marginal rim; posterior margin nearly straight, with the lateral angles terminating in abruptly pointed extremities, so short as scarcely to project as far backward as the posterior margin of the second thoracic segment. Glabella depressed nearly even with the cheeks, about two-thirds as long as the entire head, and between one-third and one-fourth the breadth of the same behind, but narrowing forward to its subtruncated anterior end, and separated from the cheeks on each side and in front by a shallow furrow; occipital furrow moderately well defined, and continued as rather deep broad furrows along the posterior margin of the cheeks out nearly to the points where the facial sutures cut the margin; lateral furrows not clearly defined in the specimens, but apparently consisting of four pairs. Facial sutures directed at first, for a short distance, forward from the inner anterior end of each eye, then curving gracefully outward as they extend forward, until near the anterior margin of the head, where they are a little wider apart than the distance between the eyes, but again curving rather abruptly inward, so as to reach the anterior margin nearly on a line with each eye; posteriorly these sutures extend at first outward, nearly at right angles to the longitudinal axis, from the posterior end of each eye, and then curve gracefully backward so as to intersect the posterior margin between one-fourth and one-third the distance from the lateral angles, inward toward the glabella. Eyes rather depressed, slightly arched outward, and separated from each other by a space somewhat less than half the entire breadth of the head, and placed less than their own length in advance of the posterior margin, and about once and a half their length behind the front margin of the head; visual surfaces narrow, and not showing any lenses under a good magnifier.

Thorax with its length bearing the proportions to that of the head, of 79 to 52, and to its own breadth, of 79 to 107, being very slightly wider near the middle than in front, and narrowing posteriorly, with gently convex lateral margins, from behind the middle to the pygidium. Axial lobe depressed, narrow, or only

about two-thirds the breadth of each lateral lobe at its anterior end, and narrowing regularly with straight sides posteriorly; segments thirteen, nearly or quite straight, and each with a small node or prominence at each end. (In some specimens these nodes seem to be wanting, while in others they do not exist on all of the segments.) Lateral lobes depressed or nearly flat; pleurae almost transverse or arching slightly backward to near the extremities, which are abruptly pointed; each with a well-defined furrow, which commences small near the anterior inner end and widens and deepens for about half way out, and then narrows and becomes more shallow, so as to die out before reaching the lateral extremities.

Pygidium subsemicircular, being rounded posteriorly, with a narrow, slightly flattened border, and somewhat rounded anterior lateral extremities; length bearing to that of the thorax the proportions of 30 to 79, and to that of the head 30 to 52, with a breadth of not quite two-thirds of that of the head; axial lobe equaling more than two-thirds the length, narrow, depressed, and showing more or less distinctly about five segments; lateral lobes much depressed, nearly twice as wide at the anterior end as the middle one, each with about three segments, which curve a little backward and become obsolete before passing upon the narrow, smooth border; segments each provided with a comparatively large longitudinal furrow, corresponding to those on the pleurae.

Entire surface apparently smooth, excepting fine radiating striae on the anterior and lateral portions of the cephalic shield that are scarcely visible without the aid of a magnifier.

Whole length, 1.60 inch; breadth of thorax, 1.07 inch; breadth of cephalic shield (somewhat flattened by pressure), about 1.12 inch; length of thorax .79 inch; length of pygidium .30 inch; breadth of pygidium .60 inch.

Discussion.—*E. kingii* (Meek) is represented by hundreds of slightly flattened nearly complete specimens. It is characterized by the relatively narrow border on the cranidium and pygidium, short genal spines on the free cheek, narrow axial lobe on the thorax, and short distal thoracic spines.

Occurrence.—Middle Cambrian, Wheeler formation, House Range, Utah.

Figured specimen.—Nearly complete carapace, USNM 15439d, length, 16 millimeters.

Elrathia? occidentalis (Walcott)

Ptychoparia occidentalis Walcott, 1884, U. S. Geol. Survey Mon. 8, p. 51, pl. 10, fig. 5.

Description.—The cranidium of this species was described in detail by Walcott (1884, p. 51).

Head within the facial sutures, exclusive of the postero-lateral limbs, quadrangular in form; glabella subconical, the sides slightly converging towards the rounded front; surface uniformly convex and marked by three pairs of moderately oblique glabellar furrows, the two posterior pairs of which are more strongly impressed and reach two-thirds the distance to the median line, the anterior pair are short and faintly defined; occipital furrow distinct; occipital ring rounded and rather under the medium size; dorsal furrows well impressed on the sides and in front of the glabella; fixed cheeks of medium width, not very convex, and sloping away gradually in front and behind; ocular ridges well marked; frontal limb extended a little beyond the fixed cheeks, slightly convex, and bordered by a flattened rim that is two-thirds as wide as the width between it and the glabella; eye-lobes of medium size; postero-lateral limbs narrow, extended, with a strongly marked continuation of the occipital furrow just within their posterior margin. The facial suture cuts very obliquely across the frontal rim of the head and abruptly recurving inward at its interior margin passes slightly inward in a direct line to the eye-lobe, back of which it is directed outward with a backward curve on the outer third of the lateral limb, to the posterior margin of the head, which it cuts at a distance from the dorsal furrow equal to the width of the base of the glabella.

Discussion.—Resser (1937, p. 10) assigned *Ptychoparia occidentalis* Walcott to *Elrathia* without a word of comment. Because only the cranidium of this species is known, it is practically impossible to give either an adequate specific diagnosis or a certain generic identification. The name should probably be restricted to the type specimen. The distinct glabellar furrows noted by Walcott are probably due in great part to the crushed nature of the type specimen.

The glabella has a more strongly rounded anterior end, and the cranidium has a relatively wider border than that of *E. kingii* (Meek).

Occurrence.—Middle Cambrian, Geddes limestone of Wheeler and Lemmon (1939), Eureka, Nev.

Figured specimen.—Holotype cranidium, USNM 24612, length, 16 millimeters.

Genus KOCHASPIS Resser, 1935

Kochaspis Resser, 1935, Smithsonian Misc. Coll., v. 93, no. 5, p. 36.
Shimer and Shrock, 1944, Index Fossils of North America, p. 611.
Rasetti, 1951, Smithsonian Misc. Coll., v. 116, no. 5, p. 225.
Paleocrepicephalus Kobayashi, 1935, Tokyo Imp. Univ., Fac. Sci., Jour., sec. 2, v. 4, pt. 2, p. 277.

Genotype.—*Crepicephalus liliana* Walcott, 1886 (p. 207, pl. 28, figs. 3, 3a, b).

Diagnosis.—Cranidium subquadrate in outline, gently to moderately rounded anteriorly. Glabella well defined by dorsal furrow, straight sided or with sides slightly bowed outward, tapered forward, bluntly rounded anteriorly. Three pairs of deep glabellar furrows present. Occipital furrow deep. Occipital ring gently to moderately arched upward. Frontal area with distinct brim and border; border gently arched upward; marginal furrow shallow on midline, broad, deep distally. Width of fixed cheeks more than one-half width of glabella; prominent ocular ridges present. Palpebral lobes situated opposite middle third of glabella, poorly defined by shallow palpebral furrow. Length of posterior limbs about equal to width of glabella at occipital furrow; marginal furrow deep. Anterior course of facial suture nearly straight forward from palpebral lobe; posterior course divergent from longitudinal cranidial axis.

Free cheek and thorax unknown.

Pygidium, excluding spines, subquadrate in outline. Axial lobe prominent, distinctly furrowed, variable in length; width slightly more than one-half width of pleural lobes. Pleural segments coalesced distally to form a pair of posteriorly directed marginal spines.

Outer surface of carapace covered with scattered large granules; inner surface smooth.

Discussion.—The cranidium of this genus differs from that of *Kochiella* Poulsen, which it most nearly resembles, by having narrower fixed cheeks and the border arched upward instead of downward in longitudinal profile.

Pygidia resemble those of *Fieldaspis* Rasetti but can be distinguished by their relatively wider axial lobe, deeper pleural furrows and interpleural grooves, and lack of a flat or concave border.

Kochaspis augusta (Walcott)

Plate 17, figure 6

Crepicephalus augusta Walcott [part], 1886, U. S. Geol. Survey Bull. 30, p. 208, pl. 28, fig. 2a.
Walcott, 1890, U. S. Geol. Survey 10th Ann. Rept., pt. 1, p. 653, pl. 96, fig. 9a.
Walcott, 1916, Smithsonian Misc. Coll., v. 64, no. 5, p. 204, pl. 29, fig. 6b.

Description.—The holotype of this species is a pygidium described by Walcott (1886, p. 208). "Pygidium with a short strong axis crossed by three furrows; pleural lobes flattened and marked by the extension of the axial furrows; posteriorly the lobes extend into points, leaving an arched posterior border between the two points of pygidium."

Discussion.—The cranidium originally assigned to this species comes from a different locality than the pygidium. Their association as parts of the same trilobite is not at all certain. The pygidium occurs with the types of *Kochaspis liliana* (Walcott), from which it differs by having one less axial segment and short, slightly convergent marginal spines.

The cranidium, recently made the type of *K. nevadensis* by Resser (1935, p. 37), is relatively narrower than that of *K. liliana* (Walcott). The difference is not great, and a statistical study of a sufficiently large sample of *K. liliana* (Walcott) might possibly show that it is not significant. Such a determination is not possible with the material at hand.

Occurrence.—Middle Cambrian, Pioche formation, Highland Range, Nev.

Figured specimens.—Holotype pygidium, USNM 15430, length, 9 millimeters; holotype of *K. nevadensis* Resser, USNM 61643, length, 12.5 millimeters.

Kochaspis liliana (Walcott)

Plate 17, figures 7, 8, 10, 11

Crepicephalus liliana Walcott, 1886, U. S. Geol. Survey Bull. 30, p. 207, pl. 28, figs. 3, 3a, b.
Walcott, 1890, U. S. Geol. Survey 10th Ann. Rept., pt. 1, p. 653, pl. 96, figs. 7, 7a–c.
Walcott, 1916, Smithsonian Misc. Coll., v. 64, no. 5, p. 209, pl. 29, figs. 5, 5a–c.
Shimer and Shrock, 1944, Index Fossils of North America, p. 611, pl. 257, fig. 16.
Kochaspis highlandensis Resser, 1935, Smithsonian Misc. Coll., v. 93, no. 5, p. 37.

Description.—Walcott (1886, p. 207) presented a detailed description of this species.

Head semicircular in outline and terminating in round, sharp, postero-lateral spines of moderate length. Glabella truncato-conical, tapering moderately to the front, height and width at the occipital furrow about equal; marked by three pairs of furrows; the two posterior extend obliquely inward and backward and the anterior pairs are nearly transverse in direction; the anterior pair is often very faintly indicated, and on the glabellas of young individuals, 2mm or 3mm in length, the furrows show only as faint depressions on the smooth surface; occipital furrows broad and well defined; occipital segment strong and moderately elevated; dorsal furrows distinct.

Fixed cheeks broad as the glabella opposite the eyes; posteriorly they broaden out in the short postero-lateral limbs, and anteriorly merge into the frontal limb, which is of moderate width, slightly convex and bordered anteriorly by a flattened margin about as broad as the distance from the front of the glabella to the slight but distinct depressions between the frontal limb and the margin; postero-lateral limbs grooved near the posterior margin by a distinct furrow. Eyes lunate, about one-third as long as the length of the glabella; a strong ocular ridge extends from the anterior end of the narrow palpebral lobe with a slightly forward direction, touching the dorsal furrow nearly, but not quite, opposite the antero-lateral angle of the glabella. Facial sutures cut the anterior margin on a line with the sides of the glabella, and extend obliquely inward and outward across the margin and then curve inward and extend to the eye; curving around the palpebral lobe, they extend obliquely outward with a slightly sigmoidal course to the posterior margin. The associated free cheek is irregularly triangular; marginal border strong and produced behind into a medium-sized, sharp spine; central area slightly convex, and marked by striae that radiate from the base of the eye towards the margin; anteriorly the border narrows to a slender point.

Thorax unknown.

Pygidium subquadrilateral in outline, with strong, slightly-diverging spines extending back from the postero-lateral angles; sides nearly straight, slightly converging posteriorly to the base of the spines; posterior margin a little concave between the spines; axial lobe prominent, convex, and reaching five-sixths of the distance between the front and back margins; the sides converging very little towards the obtusely-rounded posterior end; divided by fine transverse furrows into five segments and an obtuse terminal point; the pleural lobes are grooved by the extension of the grooves crossing the axis; the terminal spines appear to arise from the extension of the anterior segment of the pygidium. There is considerable variation in the strength and direction of the postero-lateral spines, but I find this to be true of the corresponding spines on *Crepicephalus Iowensis.*

Surface of head and pygidium with papillae of different size scattered over it, sometimes so thickly as to give a granulose appearance to it.

Discussion.—*K. liliana* (Walcott) is characterized by having the width of the cranidium between the palpebral lobes greater than the axial length, the axial length of the border equal to or greater than the axial length of the brim, and four axial segments and a pair of long slender divergent marginal spines on the pygidium.

The cranidium illustrated by Walcott (1886, pl. 28, fig. 3b) from the Pioche formation north of Bennet Springs, Highland Range, Nev., was made the type of *Kochaspis highlandensis* Resser. It has the outer surface poorly preserved but agrees in all observable characteristics with *K. liliana* (Walcott) and is considered here as a synonym of that species. The pygidium mentioned by Resser is a small specimen with three pairs of short marginal spines. It certainly does not belong to *Kochaspis* and may represent a species of *Zacanthoides*.

Occurrence.—Middle Cambrian, Pioche shale, Highland Range, Nev.

Figured specimens.—Cotypes: Cranidium, USNM 15428, length, 15 millimeters; pygidium, USNM 15428, length (not including spines), 8.5 millimeters; cranidium, called *K. highlandensis* by Resser, USNM 61640, length, 11.5 millimeters; free cheek, USNM 61641, width, 6 millimeters.

Genus MODOCIA Walcott, 1924

Modocia Walcott, 1924, Smithsonian Misc. Coll., v. 75, no. 2, p. 59.
Walcott, 1925, idem, no. 3, p. 105.
Shimer and Shrock, 1944, Index Fossils of North America, p. 629.
Palmer, 1954, in press, Jour. Paleontology.
Metisia Resser, 1937, Smithsonian Misc. Coll., v. 95, no. 22, p. 19.

Genotype.—*Arionellus* (*Crepicephalus*) *oweni* Meek and Hayden, 1861 (p. 436).

Discussion.—The writer has recently (Palmer, 1954, in press) described this genus in detail and considered *Metisia* Resser (1937, p. 19) to be a synonym.

Modocia differs from *Ehmania* Resser, with which it has been confused, by having deep dorsal and marginal furrows on the cranidium and fewer segments and a downsloping margin on the pygidium.

Modocia nevadensis Palmer, n. sp.

Plate 17, figures 12, 14, 15

Ptychoparia oweni Walcott [not Meek and Hayden], 1884, U. S. Geol. Survey Mon. 8, p. 55, pl. 10, figs. 3, 3a.

Description.—Cranidium subtrapezoidal in outline; width at palpebral lobes about equal to length; anterior margin gently rounded. Glabella elongate, tapering, rounded anteriorly, well defined by narrow dorsal furrow. Three pairs of broad, shallow glabellar furrows present. Occipital furrow straight, deep; depth at sides slightly greater than that on median line. Occipital ring moderately convex, of nearly constant width. Frontal area narrow, subequally divided into moderately to strongly arched border and gently arched brim. Marginal furrow distinct, deep; occasional suggestions of pair of depressions about opposite posterolateral corners of glabella. Fixed cheeks narrow, slightly convex, gently downsloping. Palpebral lobes distinct, moderate sized, connected to anterior end of glabella by very faint ocular ridges. Posterior limbs sharply pointed; length somewhat less than width of glabella at occipital furrow. Marginal furrow deep, distinct. Anterior course of facial suture straight forward or slightly divergent from axial line; posterior course divergent behind eye, gently curving to posterior margin.

Free cheek elongate subtriangular in outline; platform about twice as wide as arched, slightly downsloping border. Genal spine short, sharply pointed; small "spur" on inner margin.

Pygidium transverse in outline; width about twice length. Axial lobe short, bluntly terminated, tapered slightly, and extended to margin, bears 2 or 3 distinct segments. Pleural lobes marked by 5 or 6 pleural and interpleural furrows diminishing in strength posteriorly. First segment of pygidium often continued laterally into short spines. Posterior margin with faint median indentation. Border poorly developed. Surface of carapace faintly and minutely granular.

Discussion.—Walcott (1884, p. 55) considered this species to be identical to *Arionellus* (*Crepicephalus*) *oweni* Meek and Hayden from the Deadwood formation in the Black Hills of South Dakota and placed it in the genus *Ptychoparia*. He discussed but never described it, and Resser (1935, p. 25), without a word of comment, placed it in *Ehmania*. The Eureka specimens have deep dorsal and marginal furrows on the cranidium and a poorly developed pygidial border, both considered characteristics of *Modocia* that differentiate it from *Ehmania*. The cranidium of this species differs from that of *Arionellus* (*Crepicephalus*) *oweni* Meek and Hayden by being relatively narrower and more strongly arched and by having the axial length of the border about equal to that of the brim. The pygidium is identical in all observable characteristics to the pygidium of that species. The writer considers *Arionellus* (*Crepicephalus*) *oweni* Meek and Hayden, 1861, genotype of *Modocia*, and *Ptychoparia oweni* Walcott, 1884, to be congeneric, but not conspecific, and proposes the name *Modocia nevadensis* Palmer, n. sp., for the specimens illustrated by Walcott.

Occurrence.—Middle Cambrian, Hamburg limestone (lower part), Eureka Mining district, Nev.

Figured specimens.—Holotype cranidium, USNM 24610, length, 9 millimeters; pygidium, USNM 24610, length, 5 millimeters.

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INDEX

[Italic numbers indicate description]

PLATES 13–17

PLATE 13

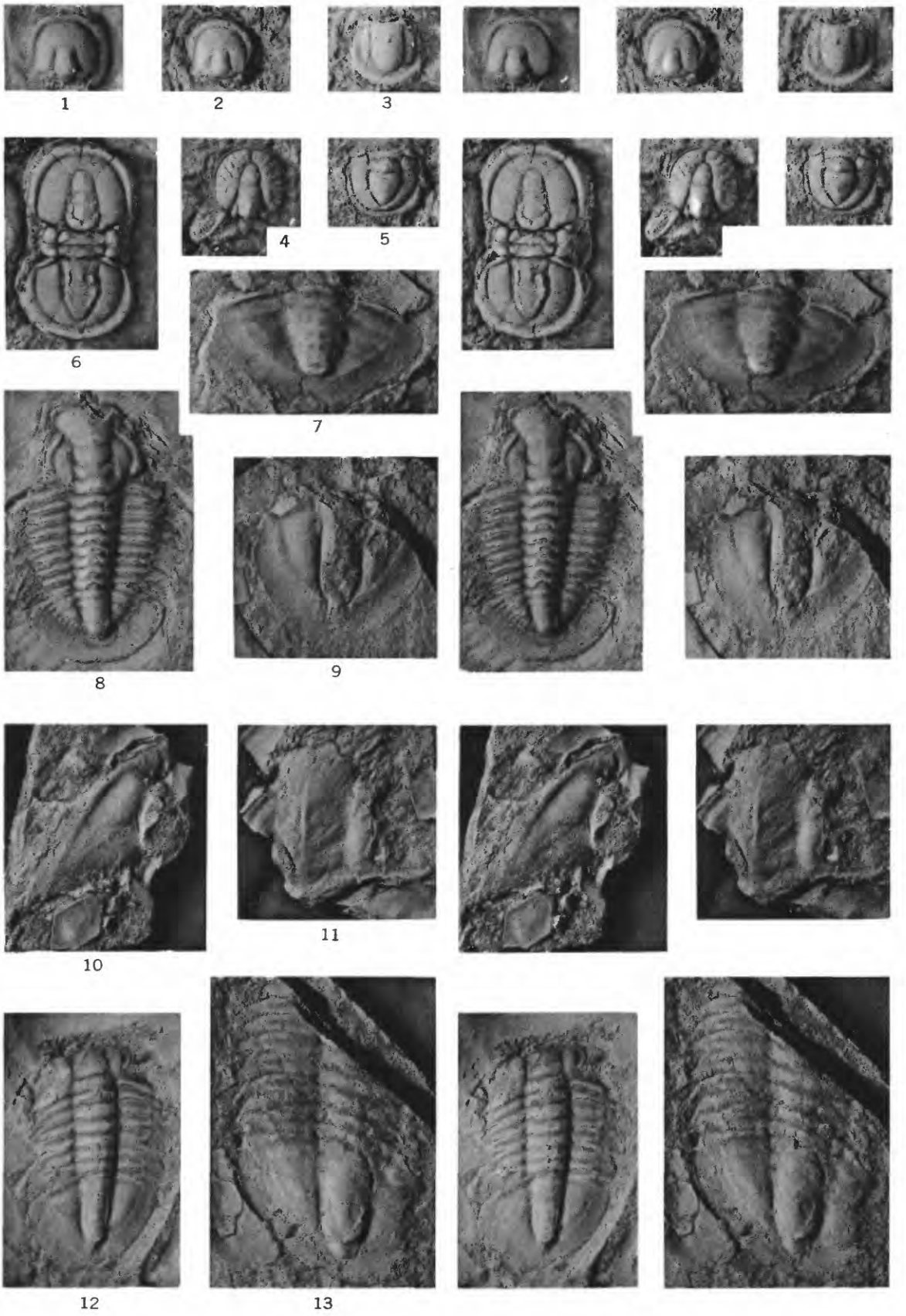
FIGURES 1–3. *Kormagnostus seclusus* (Walcott) (p. 59), ×4.
Lower part of Hamburg limestone, Eureka district, Nev.
1. Holotype cephalon, USNM 24586, from USGS coll. 58 (OS).
2. Cephalon, USNM 123353a, from USGS coll. 806 (CO).
3. Pygidium associated with cephalon in figure 2, USNM 123353b, from USGS coll. 806 (CO).

4, 5. *Ptychagnostus richmondensis* (Walcott) (p. 61), ×4.
Geddes limestone (of Wheeler and Lemmon), Eureka district, Nev.
4. Cephalon, USNM 123354, from USGS coll. 965 (CO).
5. Pygidium, USNM 123355, from USGS coll. 901 (CO).

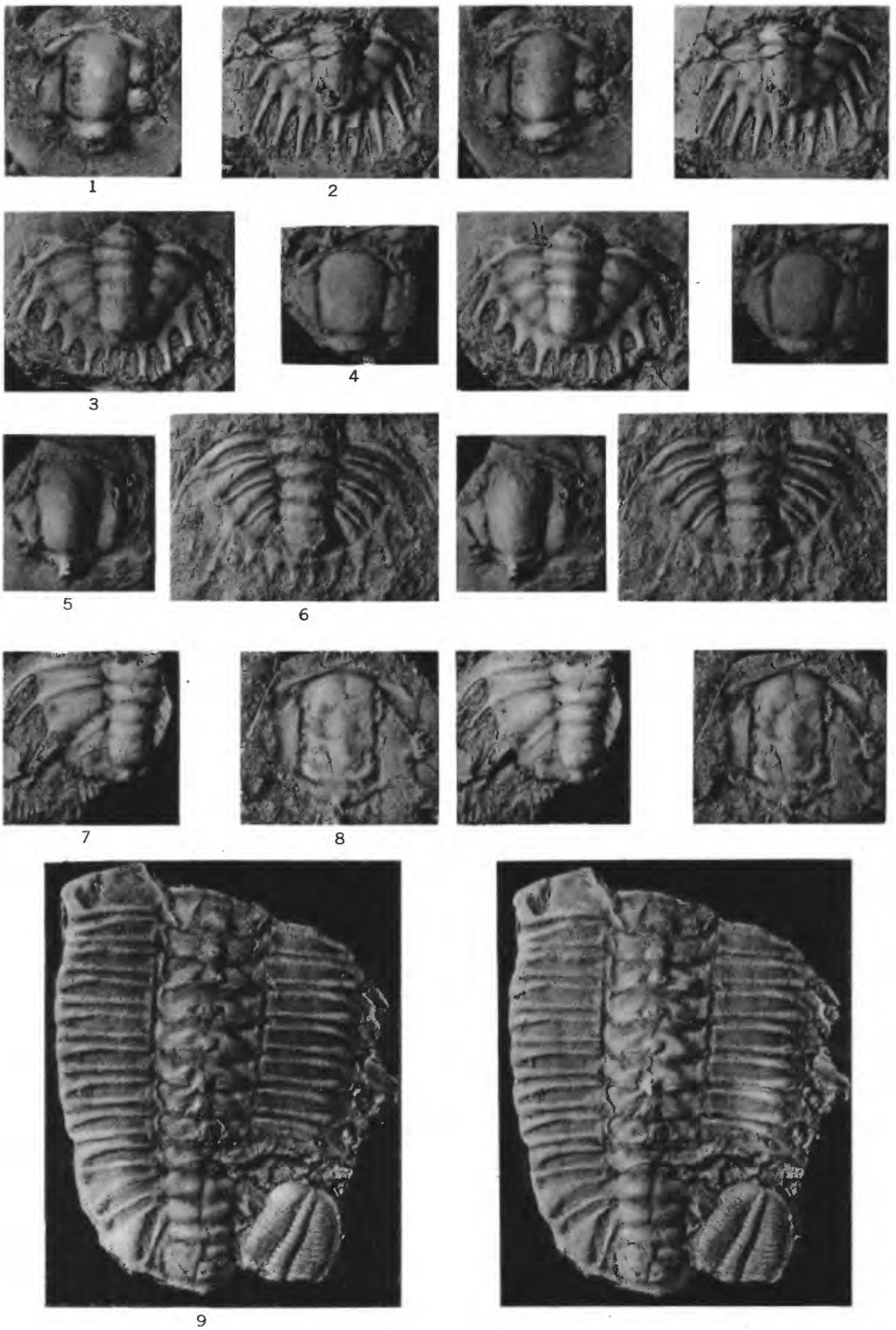
6. *Peronopsis interstrictus* (White) (p. 60), ×4.
Holotype, USNM 15405, Wheeler formation, Antelope Springs, House Range, Utah.

7, 9–13. *Glossopleura producta* (Hall and Whitfield) (p. 67).
Ophir shale (?), Oquirrh Range, Utah.
7, 10, 11, 13. Cotypes, ×1.5, USNM 15456 a–c, e from USGS coll. 329e (OS).
9. Pygidium, ×1, holotype of *Ogygia parabola* Hall and Whitfield, here considered a synonym of *G. producta* (Hall and Whitfield), USNM 15456d, from USGS coll. 329e (OS).
12. Nearly complete specimen ×1.5, USNM 123356, from USGS coll. 3c (OS).

8. *Athabaskia howelli* (Walcott) (p. 66), ×2.
Holotype, USNM 15457, from USGS coll. 31 (OS). Chisholm shale, Pioche district, Nev.



AGNOSTIDAE AND DOLICHOMETOPIDAE



DORYPYGIDAE

PLATE 14

FIGURES 1–3. *Kootenia quadriceps* (Hall and Whitfield) (p. 65).
Ute limestone, Blacksmith Fork, Bear River Range, Utah.
1. Cotype cranidium, ×3, USNM 15448a.
2, 3. Cotype pygidia, ×2, USNM 15448b, c.

4. *Kootenia? eurekensis* Resser (p. 65), ×4.
Holotype, specimen figured by Walcott (1884, pl. 9, fig. 24) as *Dicellocephalus quadriceps*, USNM 15449, USGS coll. 55b (OS). Geddes limestone (?) of Wheeler and Lemon, Eureka district, Nev.

5, 7. *Olenoides expansus* (Walcott) (p. 63), ×1.5.
Geddes limestone (of Wheeler and Lemmon), Eureka district, Nev.
5. Holotype cranidium, USNM 15450, from USGS coll. 55b (OS).
7. Associated pygidium, USNM 15450, from USGS coll. 55b (OS).

6, 8. *Olenoides wahsatchensis* (Hall and Whitfield) (p. 64), ×1.5.
Spence shale member of the Ute limestone, Wasatch Range, Utah.
6. Pygidium of *Dikellocephalus? gothicus* Hall and Whitfield considered by Walcott, 1886, and subsequent authors as a part of *O. wahsatchensis*, USNM 15447, from USGS coll. 329 (OS).
8. Holotype cranidium, USNM 15447, from USGS coll. 329 (OS).

9. *Olenoides nevadensis* Meek (p. 64), ×1.
Holotype, the only specimen of this genus ever collected from the *Elrathia kingii* beds, USNM 15453. Wheeler formation, Antelope Springs, House Range, Utah.

PLATE 15

FIGURES 1, 2. *Oryctocephalus primus* (Walcott) (p. 68), ×3.
Pioche shale, Pioche district, Nev.
1. Cotype cranidium, USNM 15427, from USGS coll. 31a (OS).
2. Cotype pygidium, USNM 15427, from USGS coll. 31a (OS).

3, 4, 6. *Holteria problematica* (Walcott) p. 66).
Lower part of Hamburg limestone, Eureka district, Nev.
3. Cotype adult cranidium, ×1, USNM 24606, from USGS coll. 58 (OS).
4. Cotype immature cranidium, ×4, USNM 24606, from USGS coll. 58 (OS).
6. Rubber cast of cotype pygidium, ×1, USNM 24606, from USGS coll. 58 (OS).

5, 7. *Zacanthoides spinosus* (Walcott) (p. 70), ×1.5.
Geddes limestone of Wheeler and Lemmon, Eureka district, Nev.
5. Pygidium, USNM 123352, from USGS coll. 900 (CO).
7. Holotype cranidium, USNM 15451, from USGS coll. 55b (OS).

8. *Alokistocare subcoronatum* (Hall and Whitfield) (p. 72), ×4.
Holotype cranidium, USNM 15442. From the Ute limestone, Blacksmith Fork, Bear River Range, Utah.

9. *Zacanthoides typicalis* (Walcott) (p. 70), ×2.
Holotype, USNM 15454, from USGS coll. 31 (OS). Chisholm shale, Pioche district, Nev.

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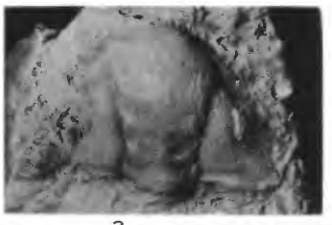

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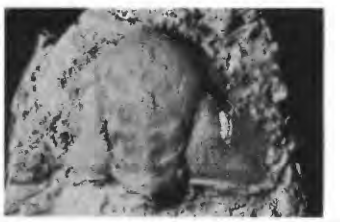

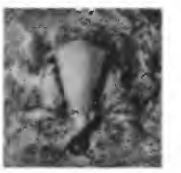

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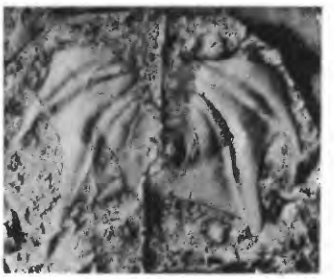

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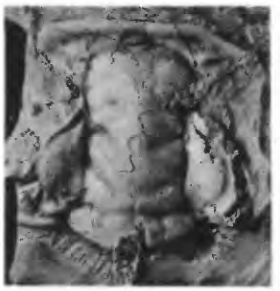

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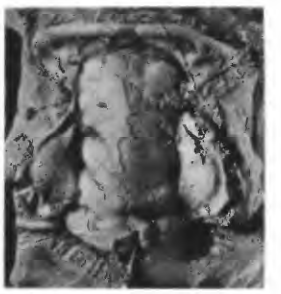

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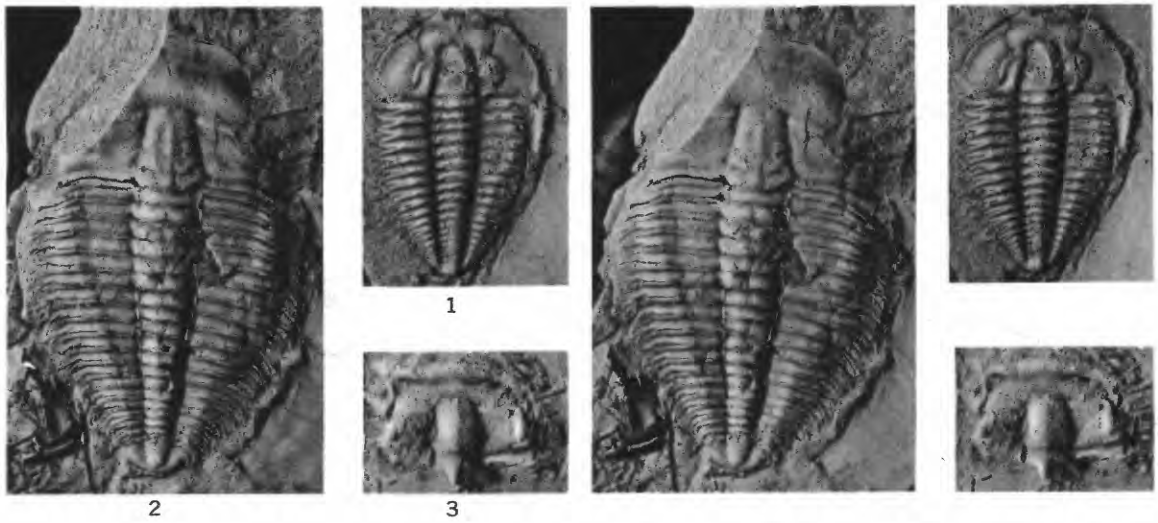
ORYCTOCEPHALIDAE, DORYPYGIDAE, ZACANTHOIDIDAE, AND PTYCHOPARIOIDEA



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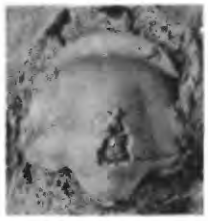

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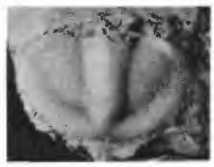

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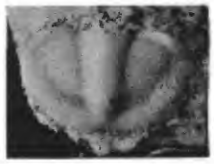

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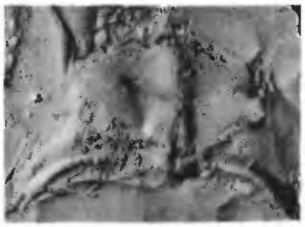

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PTYCHOPARIOIDEA

PLATE 16

FIGURES 1, 2, 5. *Alokistocare piochensis* (Walcott) (p. 72).
Chisholm shale, Pioche district, Nev.
1. Immature specimen, ×2, showing variation in width of cheeks with growth, USNM 15434, from USGS coll. 31 (OS).
2. Complete specimen, ×1.5, USNM, from 15434, USGS coll. 31 (OS).
5. Holotype cranidium, ×1, USNM 15434, from USGS coll. 31 (OS).

3. *Bolaspidella housensis* (Walcott) (p. 75), ×4.
Holotype cranidium, USNM 15443. From Wheeler formation, Antelope Springs, House Range, Utah.

4, 6. *Asaphiscus laeviceps* (Walcott) (p. 73), ×3.
Lower part of Hamburg limestone, Eureka district, Nev.
4. Holotype cranidium, USNM 24614, from USGS coll. 58 (OS).
6. Associated pygidium, USNM 24614, from USGS coll. 58 (OS).

7. *Asaphiscus wheeleri* Meek (p. 74), ×2.
Nearly perfect specimen from topotype material, USNM 15460 Wheeler formation, Antelope Springs, House Range, Utah.

8. *Eldoradia prospectensis* (Walcott) (p. 77), ×4.
Holotype cranidium, USNM 15441, from USGS coll. 52a (OS). Secret Canyon shale?, Eureka, district, Nev.

9, 10. *Eldoradia linnarssoni* (Walcott) (p. 77), ×2.
Secret Canyon shale, Eureka district, Nev.
9. Holotype cranidium, USNM 24611, from USGS coll. 58 (OS).
10. Holotype of *Eldoradia lata* Resser, here considered a synonym of *E. linnarssoni*, USNM 90669, from USGS coll. 58(OS).

PLATE 17

FIGURES 1–5. *Ehmaniella quadrans* (Hall and Whitfield) (p. 76), ×3.
Figures 1, 2, and 3 are all from one piece of indurated shale.
Figures 4 and 5 show the natural convexity of the specimens. Spence shale, member of the Ute formation, Wasatch Range, Utah.
1. Holotype cranidium, USNM 15432, from USGS coll. 329 (OS).
2. Rubber cast of pygidium, USNM 15432, from USGS coll. 329 (OS).
3. Free cheek, USNM 15432, from USGS coll. 329 (OS).
4. Cranidium, USNM 123351a, from USGS coll. 20× (OS).
5. Pygidium, USNM 123351b, from USGS coll. 20× (OS).

6. *Kochaspis augusta* (Walcott) (p. 80), ×2.
Holotype pygidium, USNM 15430, from USGS coll. 31a (OS). Pioche shale, Pioche district, Nev.

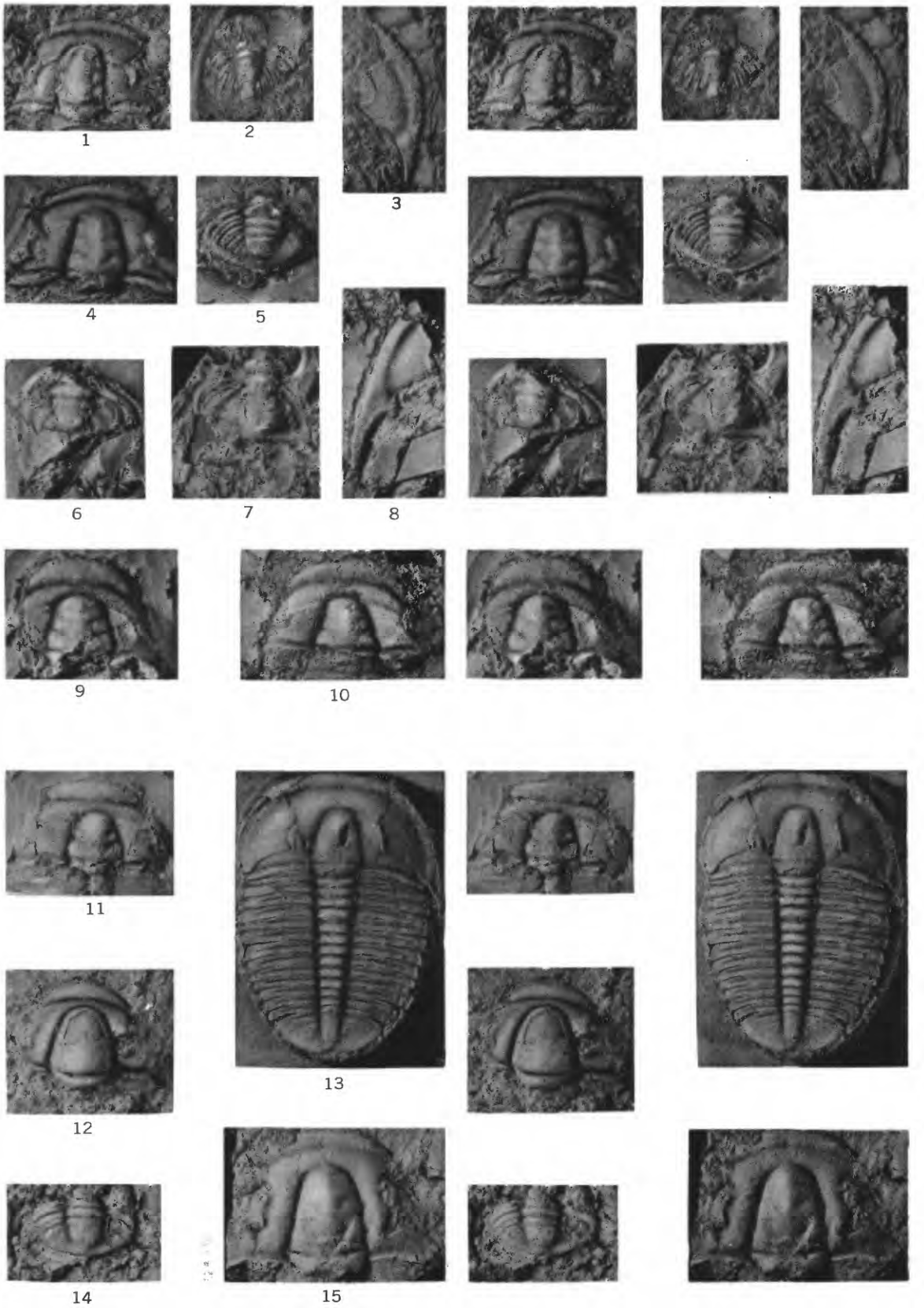
7, 8, 10, 11. *Kochaspis liliana* (Walcott) (p. 80).
Pioche shale, Pioche district, Nev.
7. Rubber cast of cotype pygidium ×1.5, USNM 15428, from USGS coll. 31a (OS).
11. Cotype cranidium ×1.5, USNM 15428, from USGS coll. 31a (OS).
8. Free cheek, ×2, USNM 61641, from USGS coll. 30 (OS).
10. Holotype cranidium, ×1.5, of *Kochaspis highlandensis* Resser here considered a synonym of *K. liliana*, USNM 61640, from USGS coll. 30 (OS).

9. *Kochaspis nevadensis* Resser (p. 80), ×1.5.
Holotype cranidium, illustrated by Walcott (1886, pl. 28, fig. 2) as that of *K. augusta*, USNM 61643, from USGS coll. 30 (OS). Pioche shale, Pioche district, Nev.

12, 14. *Modocia nevadensis* Palmer, n. sp. (p. 81), ×2.
Lower part of Hamburg limestone, Eureka district, Nev.
12. Holotype cranidium, figured by Walcott (1884, pl. 10, fig. 3) as *Ptychoparia oweni*, USNM 24610, from USGS coll. 58 (OS).
14. Pygidium figured by Walcott (1884, pl. 10, fig. 3a), USNM 24610, from USGS coll. 58 (OS).

13. *Elrathia kingii* (Meek) (p. 78), ×3.
Nearly perfect cotype specimen, USNM 15439d. Wheeler formation, Antelope Springs, House Range, Utah.

15. *Elrathia occidentalis* (Walcott) (p. 79), ×1.5.
Holotype cranidium, USNM 24612, from USGS coll. 55a (OS). Geddes limestone of Wheeler and Lemmon, Eureka district, Nev.



PTYCHOPARIOIDEA