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# CAMBRIAN GEOLOGY AND PALEONTOLOGY

IV

No. 3.—FAUNA OF THE MOUNT WHYTE FORMATION

(WITH PLATES 8 TO 13)

BY  
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## IV

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#### INTRODUCTION

The name Mount Whyte formation was proposed in 1908<sup>1</sup> for a series of alternating bands of limestone and siliceous and calcareous shale found on the north slope of Mount Whyte with a total thickness of 386 feet (117.7 m.); on the south slope of Mount Bosworth 390 feet (118.9 m.); on the north slope of Mount Stephen above railroad tunnel 315 feet (96 m.), and on the southeast slope of Castle Mountain 248 feet (75.5 m.). The Mount Whyte and the Castle Mountain sections are on the eastern slope of the Continental Divide in Alberta, and the Mount Bosworth and Mount Stephen sections on the western slope in British Columbia, Canada.

The included fauna was referred to as of Lower Cambrian age and with it by inference a fauna of undetermined stratigraphic position,<sup>2</sup> now known as the *Albertella* fauna of the Middle Cambrian.

<sup>1</sup> Smithsonian Misc. Coll., Vol. 53, 1908, p. 4.

<sup>2</sup> For explanation of this reference see Smithsonian Misc. Coll., Vol. 67, pp. 9-12.

In 1914 Mr. L. D. Burling concluded after a thorough and admirable study that on paleontological evidence the *Albertella* fauna was of Middle Cambrian age and that the specimens of *Olenellus* found in the Mount Whyte formation were examples of recurrence.<sup>1</sup> On the basis of this conclusion Burling placed the Mount Whyte formation in the Middle Cambrian.

The discovery that the *Albertella* fauna occurs at an horizon 500 feet (152.4 m.) above the Mount Whyte formation materially affects this conclusion.<sup>2</sup>

Several stratigraphic sections that include the Mount Whyte formation have been published<sup>3</sup> and others will be after the conclusion of field work in 1917. The presentation and discussion of all sections studied will be given in a future paper on the stratigraphy of the formation.

#### STRATIGRAPHIC POSITION OF THE FAUNA

All of the stratigraphic sections in their upper portion have varying thicknesses of calcareo-arenaceous beds and bands of oolitic limestone. In the upper layers of limestone there is usually a well-marked fauna and at this horizon in three sections, at Mount Assiniboine, Ptarmigan Peak, and Mount Stephen, the fauna includes a representation of the genus *Crepicephalus*, which attains its greatest development in the Middle and Upper Cambrian of America, where 16 species or more are known, the greater proportion being in the Upper Cambrian.<sup>4</sup> The central portions of the sections include siliceous shales and finely arenaceous beds and relatively few fossils, while the beds toward the base are usually thin-bedded, more or less slightly calcareous sandstones, and contain a characteristic Lower Cambrian fauna with abundant fragments of both *Olenellus* and *Mesonacis*, and without traces of forms usually considered characteristic of the Middle Cambrian fauna.

The fauna of the upper oolitic limestone in the Mount Stephen section at locality 58k, about 5 feet (1.5 m.) below the top of the Lower Cambrian in thin-bedded bluish-black and gray limestone (3 feet) forming 1 of Mount Whyte formation, and the interbedded limestone at the top of 2, Mount Stephen section; just above the tunnel, north shoulder of Mount Stephen, 3 miles (4.8 km.) east of Field, British Columbia, includes:

<sup>1</sup> Canadian Geol. Surv., Museum Bull., No. 2, Geol. Ser., No. 17, 1914, p. 36.

<sup>2</sup> Smithsonian Misc. Coll., Vol. 67, 1917, pp. 12-18.

<sup>3</sup> Idem, Vol. 53, 1908, pp. 212-215.

Canadian Alpine Journal, Vol. 1, No. 2, 1908, pp. 240-242.

Smithsonian Misc. Coll., Vol. 67, 1917, pp. 15, 16.

<sup>4</sup> Idem, Vol. 64, 1916, pp. 203-204.

*Acrotreta sagittalis taconica* (Walcott)  
*Helcionella elongata* Walcott  
*Scenella varians* Walcott  
*Parmophorella* sp.  
*Hyalithes billingsi* Walcott  
*Ptychoparia clusia* Walcott  
*Ptychoparia thia* Walcott  
*Ptychoparia* (pygidia)  
*Olenopsis agnesensis* Walcott  
*Crepicephalus celer* Walcott  
*Bathyriscus (Poliella) primus* Walcott

In the Ptarmigan Peak section the upper oolitic limestone at locality 63a, east base of Ptarmigan Peak, 5.5 miles (8.8 km.) in an air line northeast of Lake Louise station on the Canadian Pacific Railway, Alberta, includes:

*Nisusia (Jamesella) lowi* Walcott  
*Wimanella catulus* Walcott  
*Hyalithes billingsi* Walcott  
*Ptychoparia ? cercops* Walcott  
*Crepicephalus cecinna* Walcott

At the Gog Lake section, locality 62w, No. 1 of section; oolitic limestone; about 400 feet (123 m.) below summit of ridge above Gog Lake below Wonder Pass on Continental Divide, in British Columbia, 19 miles (30.4 km.) southwest of Banff, Alberta, the fauna has several species that occur at localities 58k, 63a above,<sup>1</sup> and 61d (Footnote, p. 64), and includes:

*Archæocyathus (A.) atreus* Walcott  
*Kutorgina* cf. *cingulata* Billings  
*Micromitra (Paterina) labradorica* (Billings)  
*Nisusia (Jamesella) lowi* Walcott  
*Acrotreta sagittalis taconica* (Walcott)  
*Helcionella elongata* Walcott  
*Scenella varians* Walcott  
*Hyalithellus ?* sp. undt.  
*Hyalithes billingsi* Walcott  
*Crepicephalus cecinna* Walcott  
*Ptychoparia* cf. *gogensis* Walcott  
*Ptychoparia skapta* Walcott  
*Ptychoparia thia* Walcott  
*Olenopsis cleora* Walcott  
*Dorypyge damia* Walcott

The fauna listed from the three localities gives a general conception of the fauna associated with *Crepicephalus* in the upper portion of the formation. Its relations now appear to be more with the

<sup>1</sup> It must be recalled that all collections were obtained as incidental to stratigraphic work and are necessarily a very imperfect representation of the entire fauna at each locality and horizon; future thorough collections should yield much additional data.

Mount Whyte than with the Ptarmigan fauna, but further field work may change this view.<sup>1</sup>

The fauna of the central and lower portions of the formation is given in the following table of genera and species:

Genera and species	Position in formation		
	Lower	Middle	Upper
<i>Archæocyathus (A.) atreus</i> Walcott.....	..	..	×
<i>Gogia prolifica</i> Walcott .....	..	×	..
<i>Micromitra (Paterina) charon</i> Walcott.....	..	×	×
<i>Micromitra (Paterina) labradorica</i> (Billings).....	..	..	×
<i>Micromitra (Iphidella) pannula</i> (White).....	..	×	×
<i>Kutorgina</i> cf. <i>cingulata</i> Billings .....	..	..	×
<i>Obolus damo</i> Walcott .....	..	×	..
<i>Acrotreta sagittalis taconica</i> (Walcott).....	..	×	×
<i>Acrothele clitus</i> Walcott.....	..	×	..
<i>Nisusia (Jamesella) lowi</i> Walcott.....	..	×	×
<i>Nisusia festinata</i> (Billings).....	×	..	..
<i>Wimanelia catulus</i> Walcott .....	..	..	×
<i>Helcionella elongata</i> Walcott.....	..	×	×
<i>Hyalithes billingsi</i> Walcott .....	×	×	×
<i>Hyalithes</i> cf. <i>carinatus</i> Matthew .....	..	×	..
<i>Hyalithes</i> sp. undt. ....	×	..	..
<i>Hyalithellus</i> cf. <i>micans</i> Billings.....	×	×	..
<i>Hyalithellus</i> sp. undt.....	..	..	×
<i>Pelagiella</i> sp. undt. (a).....	..	..	×
<i>Pelagiella</i> sp. ....	..	..	×
<i>Parmophorella</i> sp. ....	..	..	×
<i>Scenella varians</i> Walcott.....	×	×	×
<i>Shafferia cisina</i> Walcott.....	..	..	×
<i>Bradoria</i> (large species).....	..	×	..
<i>Hymenocaris</i> sp. undt.....	..	×	..
<i>Aluta</i> (small species).....	..	×	..
<i>Agraulos charops</i> Walcott.....	×	..	..

<sup>1</sup> Almost at the top of the oolitic limestone in the Mount Shaffer section at locality 61d, southwest slope of Mount Shaffer on Canyon side, on trail to Lake McArthur, 5.5 miles (8.8 km.) south of Hector Station, on Canadian Pacific Railroad, British Columbia, the fauna is Lower Cambrian in character and includes:

<i>Micromitra (Paterina) labradorica</i> (Billings)	<i>Shafferia cisina</i> Walcott
<i>Micromitra (Iphidella) pannula</i> (White)	<i>Corynexochus senectus</i> (Billings)
<i>Acrotreta sagittalis taconica</i> (Walcott)	<i>Agraulos ? unca</i> Walcott
<i>Nisusia (Jamesella) lowi</i> Walcott	<i>Zacanthoides</i>
<i>Scenella varians</i> Walcott	<i>Ptychoparia lux</i> Walcott
<i>Pelagiella</i> sp. undt. (a)	<i>Ptychoparia</i> sp. undt.
	<i>Mesonacis gilberti</i> (Meek)

Genera and species	Position in formation		
	Lower	Middle	Upper
<i>Agranlos ? unca</i> Walcott.....	..	..	×
<i>Olenopsis agncensis</i> Walcott.....	..	×	×
<i>Olenopsis cleora</i> Walcott.....	..	×	×
<i>Olenopsis crito</i> Walcott.....	×	..	..
<i>Olenopsis leuka</i> Walcott.....	..	×	..
<i>Ptychoparia adina</i> Walcott.....	..	×	..
<i>Ptychoparia carina</i> Walcott.....	..	×	..
<i>Ptychoparia</i> cf. <i>carina</i> Walcott.....	..	×	..
<i>Ptychoparia ? cercops</i> Walcott.....	..	×	×
<i>Ptychoparia ? cleadas</i> Walcott.....	×	×	..
<i>Ptychoparia cleon</i> Walcott.....	×	..	..
<i>Ptychoparia clusia</i> Walcott.....	..	..	×
<i>Ptychoparia cossus</i> Walcott.....	..	..	×
<i>Ptychoparia cuncas</i> Walcott.....	×	..	..
<i>Ptychoparia</i> cf. <i>cuncas</i> Walcott.....	..	×	..
<i>Ptychoparia gogensis</i> Walcott.....	..	..	×
<i>Ptychoparia lux</i> Walcott.....	..	..	×
<i>Ptychoparia perola</i> Walcott.....	..	×	..
<i>Ptychoparia pia</i> Walcott.....	×	×	..
<i>Ptychoparia</i> cf. <i>pia</i> Walcott.....	..	×	..
<i>Ptychoparia skapta</i> Walcott.....	..	..	×
<i>Ptychoparia thia</i> Walcott.....	×	×	×
<i>Ptychoparia</i> sp. undt.....	..	..	×
<i>Crepicephalus cecinna</i> Walcott.....	..	..	×
<i>Crepicephalus celer</i> Walcott.....	..	..	×
<i>Dorypyge damia</i> Walcott.....	..	..	×
<i>Corynexochus senectus</i> (Billings).....	..	×	×
<i>Corynexochus (Bonnia) fieldensis</i> Walcott.....	×	×	..
<i>Mesonacis gilberti</i> (Meek).....	×	×	×
<i>Olenellus canadensis</i> Walcott.....	×	×	×
<i>Olencllus</i> sp. undt.....	..	..	×
<i>Bathyriscus (Policlla) primus</i> Walcott.....	..	×	×
<i>Bathyriscus</i> sp. undt.....	..	×	..

## NOTES ON THE FAUNA

One of the striking features of the 28 genera and 60 species of the Mount Whyte fauna is the presence of several species common to it and to the Lower Cambrian fauna of Newfoundland and the Champlain Valley of Vermont. In order to make this clear I have illustrated on plate 10, *Corynexochus (Bonnia) parvulus* (Billings) from the Atlantic Province (figs. 1, 1a-c) and beside it *C. (B.)*

*fieldensis* (Walcott) (figs. 2, 2a-c) from British Columbia; and on plate 9, *Corynexochus senectus* (Billings) from the Atlantic Province (figs. 1, 1a-d) and beside it specimens considered identical from British Columbia (figs. 2, 2a-c). *Mesonacis vermontana* (Hall) (fig. 3) from the Atlantic Province is the representative of *Mesonacis gilberti* (Meek) (fig. 4) from British Columbia. All of these species have about the same range of individual variation both in the Atlantic Province and British Columbia.<sup>1</sup>

Other species common to the Atlantic Province Lower Cambrian fauna and the Mount Whyte fauna are *Micromitra* (*Paterina*) *labradorica* (Billings), *Kutorgina* cf. *cingulata* (Billings), *Acrotreta sagittalis taconica* (Walcott), and *Nisusia festinata* (Billings).

There are several species of *Ptychoparia* from Lower Cambrian formations elsewhere that are very closely related to species from the Mount Whyte formation. These are now illustrated on plates 11 and 12, for the Mount Whyte species, and on plates 14 and 15,<sup>2</sup> for the species of other formations. *Ptychoparia cuneas* and *P. cossus* (pl. 11) may be compared with *P. crates* and *P. crantos* (pl. 15) from Bic Harbor on the Lower St. Lawrence River, *P. skapta* (pl. 12, fig. 9) and *P. deldon* (pl. 15, fig. 2), *P. thia* (pl. 12, fig. 6) and *P. adamsi* (pl. 14, fig. 8a). With larger collections the allied species from the two sides of the continent would undoubtedly be much increased in number.

The presence of such a strong connecting series of forms at such widely separated localities and so far north on the continent indicates a northern origin of the later phases of the Lower Cambrian or *Olenellus* fauna.

The trilobites, other than the Mesonacidae, indicate the rapid approach of the large series of genera and species that mark the Middle Cambrian fauna of North America. The Conocoryphidae is represented by forms that range throughout the Cambrian although their range of variation may be sufficient to justify applying specific names to the varieties from the Lower, Middle and Upper Cambrian. *Ptychoparia pia* (pl. 12, fig. 8) is an illustration, also *P. ? cleadas* (pl. 12, fig. 2).

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<sup>1</sup> Comparisons of the eastern and western forms of *Corynexochus senectus* may be found in observations on the species made by me in 1916. Smithsonian Misc. Coll., Vol. 64, 1916, pp. 321-322.

<sup>2</sup> Plates 14 and 15 will accompany a paper on certain Lower Cambrian genera and species of trilobites which will be issued as Number 4 of this volume on Cambrian Geology and Paleontology.

The generic relations of the Mount Whyte fauna to the superjacent Ptarmigan formation *Albertella* fauna is close despite the 500 feet (152.4 m.) of barren strata between the two faunas. Of the 28 genera of the Mount Whyte fauna 13 are represented in the *Albertella* fauna, and of the genera not present in the *Albertella* fauna 3 occur above it in the Stephen formation. More complete collections will undoubtedly increase the number of genera common to the two and at the same time may increase the number that are restricted to the Mount Whyte fauna.

*Acknowledgments.*—The drafts of the descriptions of species of *Ptychoparia* for this and other papers to follow were drawn up by Dr. Julia Gardner, who studied the material with great care.

The profiles used in illustration are by Miss Frances Wiëser, and where it was necessary to have the photographs retouched in order to bring out characters not readily photographed the work has been done by her.

#### DESCRIPTION OF GENERA AND SPECIES

##### ARCHÆOCYATHUS (ARCHÆOCYATHELLUS) ATREUS, new species

Plate 8, figs. 2, 2a

This species is represented by two examples that are illustrated by figures 2, 2a. The specimen represented by figure 2 varies in diameter from 2.2 mm. to 1.4 mm., and has a total length of 14 mm. A cross section shows a thick outer wall (fig. 2') but no structural detail, as the calcite forming it is in a crystalline condition except in one place of the section where there is a trace of what may have been two septa. On the exterior surface in addition to the swelling of the wall there are concentric growth lines and slight depressions; no cells have been observed.

The nearest related species as indicated by exterior form is *A. (A.) dwighti* Walcott<sup>1</sup> from the Lower Cambrian of eastern New York. Both are small undulating forms, but unfortunately no further comparison can be made as we do not know the structure of the wall of *A. (A.) atreus*.

*Formation and locality.*—Lower Cambrian: (62w) Mount Whyte formation; oolitic limestone, about 400 feet (123 m.) below summit of ridge above Gog Lake, below Wonder Pass on Continental Divide, in British Columbia, 19 miles (30.4 km.) southwest of Banff, Alberta, Canada.

<sup>1</sup> Tenth Ann. Rept. U. S. Geol. Survey, 1891, pl. 54, figs. 4, 4a.

## Family EOCYSTIDÆ Bather

*Eocystidæ* BATHER, 1900, Treatise on Zoölogy, Lankester, Pt. 3, p. 48.

**GOGIA**, new genus

All that is known of *Gogia* is included in the description of the genotype, *Gogia prolifica*. The form of the calyx and the character of the plates distinguish it from *Eocystites* as represented by the single plate described by Billings or by the species *E. ? ? longidactylus* Walcott,<sup>1</sup> which is the only described species sufficiently well preserved to indicate what *Eocystites* may possibly include.

*Genotype*.—*Gogia prolifica* Walcott.

*Stratigraphic range*.—As far as known *Gogia* is confined to a massive band of calcareo-arenaceous shales 250 feet (76 m.) below the oolitic limestone at the summit of the Mount Whyte formation of the Lower Cambrian.

*Geographic distribution*.—As far as known, it is confined to the vicinity of Wonder Pass southwest of Banff, Alberta.

**GOGIA PROLIFICA**, new species

Plate 8, figs. 1, 1a-b

*Calyx*.—Form: As seen flattened on the shale the outline is that of a narrow isosceles triangle pointing downward. The stem is attached to the apex of the triangle as inverted. A calyx 27 mm. in length has a width across the top of 12 mm. The largest specimen has a length of 30 mm. The plates of the calyx are polygonal, varying in size and form. The outer surface of the plates appears to have been roughened and the inner surface to have had a groove running from the central depressed area out to each angle on the margin of the plate; the casts of these grooves are shown by figure 1a. The exterior of the plates is known only from the casts in the shale as the plates have usually been removed by solution of the calcite forming them.

The arms (eight on one specimen) are long, very slender, and formed of numerous plates in a biserial arrangement and with a narrow ambulacral furrow on the inner side.

The stem is slender, tapering gradually and formed of numerous elongate and round, thick, tumid plates varying in size. The elongate plates form the upper part of the stem to where it joins the calyx, and the round plates the lower portion out to near the end where a group of minute round plates occur. The round plates appear to have been smooth, and the oval elongate plates tuberculated.

<sup>1</sup> Bull. U. S. Geol. Surv., No. 30, 1886, p. 94.

*Observations.*—This genus and species differ from described forms by the shape of the calyx and plates. The elongate arms and stem resemble the arms and stem of *Eocystites* ?? *longidactylus* Walcott,<sup>1</sup> but they differ in details.

So far as known to me, this is the oldest cystidian of this type. It occurs at an horizon 1,000 feet (304.8 m.) or more below the zone of *Eocystites* ?? *longidactylus*.

*Formation and locality.*—Lower Cambrian: (62x) Mount Whyte formation; Silici-calcareous shale, on ridge above Gog Lake, below Wonder Pass, on Continental Divide, in British Columbia, 19 miles (30.4 km.) southwest of Banff, Alberta, Canada.

#### MICROMITRA (PATERINA) CHARON, new species

Plate 10, figs. 3, 3a-b

Some specimens of this species were confused with *M. (P.) wapta* Walcott<sup>2</sup> when collected in the field. It differs from the latter in form and in having a finely reticulated surface. It is more closely related to *M. (I.) pannula*,<sup>3</sup> but it differs in having a much more finely reticulated surface and in the more elongate outline of the valves when they are undistorted (see figs. 1, 1b).<sup>3</sup> The largest valve observed has a length of 8 mm.

This shell is abundant on Mount Odaray at the type locality.

*Formation and locality.*—Lower Cambrian: (61c) Mount Whyte formation; dark siliceous shale, east slope of southeast ridge of Mount Odaray, 7.5 miles (12 km.) south of Hector, on the Canadian Pacific Railway, British Columbia, Canada.

#### OBOLUS DAMO, new species

Plate 10, figs. 6, 6a

This little shell is related to *Obolus smithi* from the Lower Cambrian Montevallo shales of Alabama,<sup>4</sup> from which it differs in its more circular outline. It also differs in the same manner from another Lower Cambrian species, *O. prindlei*<sup>5</sup> from the *Olenellus*-bearing limestone of eastern New York.

The shells occur in a fine-grained, hard shaly arenaceous rock in which very little of the original shell is preserved. The interior cast

<sup>1</sup> Bull. U. S. Geol. Survey, No. 30, 1886, p. 94, pl. 6, figs. 1, 1a-c. Pack: Journ. Geol., Chicago, Vol. 14, 1906, p. 3, pl. 1, figs. 1, 1a.

<sup>2</sup> Monogr. U. S. Geol. Survey, No. 51, 1912, p. 357.

<sup>3</sup> Idem, p. 361, pl. 4.

<sup>4</sup> Idem, p. 416.

<sup>5</sup> Idem, p. 409, pl. 27, figs. 3, 3a-c.

of a ventral valve shows a broad visceral area of the type of that in *Obolus apollinis* Eichwald.<sup>1</sup>

*Formation and locality.*—Lower Cambrian: (63g) Mount Whyte formation; greenish arenaceous shale, southwest slope of Mount Temple, about 600 feet (184.6 m.) above base of Pinnacle Pass, and 1500 feet (461.5 m.) above upper portion of Paradise Valley, and south of Lake Louise, Alberta, Canada.

#### ACROTHELE CLITUS, new species

Plate 10, figs. 4, 4a-c

This species differs from *Acrothele colleni* of the Ross Lake shale of the Ptarmigan formation, with which I had identified it in my field notes of 1908,<sup>2</sup> in having a uniformly smaller size and in the presence in the dorsal valve of a very long and strong median ridge, in this respect resembling *Acrothele bellula* of the Middle Cambrian of Alabama.<sup>3</sup>

The largest specimens in the collection have a diameter of 4 mm. and are very much flattened in the fine siliceous shale. The outer surface is marked by concentric striæ and lines of growth and a few fine radiating lines.

*Formation and locality.*—Lower Cambrian: Mount Whyte formation; (35e) Lake Agnes shale, amphitheater between Popes Peak and Mount Whyte, southwest of Lake Agnes and 3 miles (4.8 km.) west-southwest of Lake Louise station, on the Canadian Pacific Railroad, in western Alberta; also (57e) Mount Stephen section; just above the tunnel, north shoulder of Mount Stephen, 3 miles (4.8 km.) east of Field, British Columbia, Canada.

#### WIMANELLA CATULUS, new species

Plate 10, figs. 5, 5a-c

This is a more elongate form than *Wimanella simplex* Walcott of the Ptarmigan formation when specimens preserved in a similar matrix are compared. This is best shown by examining figure 8,<sup>4</sup> which illustrates a specimen of *W. simplex* from the limestone of the Ptarmigan formation, and figures 5, 5b, plate 10, illustrating *W. catulus* in this paper. Several of the specimens from the two limestones have the same outline, but in such instances the convexity of

<sup>1</sup> Monogr. U. S. Geol. Survey, Vol. 51, 1912, pl. 7, figs. 1-6.

<sup>2</sup> Smithsonian Misc. Coll., Vol. 53, p. 214, 3 of section.

<sup>3</sup> U. S. Geol. Survey, Monogr. No. 51, 1912, pl. 58, figs. 5f, 5h.

<sup>4</sup> Smithsonian Misc. Coll., Vol. 67, 1917, pl. 4.

the specimens is quite different. Thus figure 5, plate 10 (this paper) is a strongly convex ventral valve and yet in outline it is much like the dorsal<sup>1</sup> valve represented by figure 8a, plate 4 (Vol. 67, No. 2, Smithsonian Misc. Coll.).

The two species are closely related although there is about 500 feet (152.4 m.) of limestone between their respective positions in the section.

Of the known species of *Wimanella* three occur in strata referred to the Lower Cambrian and four to the Middle Cambrian.

*Formation and locality.*—Lower Cambrian: (63a) Mount Whyte formation; oolitic limestone about 130 feet (40 m.) above arenaceous shaly beds; east base of Ptarmigan Peak, 5.5 miles (8.8 km.) in an air line northeast of Lake Louise station on the Canadian Pacific Railway, Alberta, Canada.

#### SHAFFERIA, new genus

The species on which this genus is based does not appear to fall under any described genus. It has a carapace that suggests that of *Burgessia*,<sup>2</sup> but it has a thick, strong, and ornamented carapace, while that of *Burgessia* is smooth and very delicate. It may be that I misinterpret the species and that it is one of the *Discinocarina* and the notch is anterior and not posterior in position. The thick test and deep notch certainly suggest its belonging with the *Discinocarina*.

All that is known of the genus is given under the description of the type species.

*Genotype.*—*Shafferia cisina* Walcott.

*Stratigraphic range.*—This is limited to a thin layer of limestone near the summit of the Mount Whyte formation.

*Geographic distribution.*—Southwest slope of Mount Shaffer on trail to Lake McArthur, British Columbia, Canada.

The generic name is derived from Shaffer, the name of the mountain from which *Shafferia cisina* was collected.

#### SHAFFERIA CISINA, new species

Plate 11, figs. 8, 8a

Of this species only a single carapace is known. This is bent over along the median line and strongly notched posteriorly. The general form is shown by figure 8 and a side view by figure 8a. The test is

<sup>1</sup> By misprint named ventral valve.

<sup>2</sup> Smithsonian Misc. Coll., Vol. 57, 1912, p. 177, pl. 27, figs. 1, 3.

rather thick and marked by flat, irregular ridges that are subparallel to the outer margin and almost transverse across the central portion.

The carapace is 3 mm. in length along the medial line and about 5 mm. in width.

*Formation and locality.*—Lower Cambrian: (61d) Mount Whyte formation; oolitic limestone, southwest slope of Mount Shaffer on Canyon side, on trail to Lake McArthur, 5.5 miles (8.8 km.) south of Hector Station, on Canadian Pacific Railroad, British Columbia, Canada.

**AGRAULOS CHAROPS, new species**

Plate 13, figs. 2, 2a

Species known from an imperfect cranidium.

*Cephalon.*—Cranidium small, evenly convex. Glabella a little more than two-thirds the length of the cranidium, rather strongly elevated along the medial line which is highest near the occipital ring and slopes very gradually from the ring to the anterior extremity; dorsal furrows linear, distinct, gradually converging to the broadly rounded anterior extremity which is about three-fourths as wide as the base; anterior furrow narrow and shallow; glabellar furrows very obscure; occipital groove rather broad, a little broader and more shallow medially than laterally; occipital ring narrow laterally, slightly expanded medially. Fixed cheeks low, wide and gently convex, the distance from the palpebral lobe to the dorsal furrow almost as great as the width of the glabella; postero-lateral lobe imperfectly preserved; posterior groove narrow and quite deep at the axial termination opposite the occipital ring, neither so narrow nor so deep away from the axis, and cutting off an increasingly wider posterior margin. Palpebral lobe small and inconspicuous, medial in position with respect to the glabella exclusive of the occipital ring. Palpebral ridge indicated only by the obtuse angulation of the cheek. Frontal limb and border not clearly differentiated, the two together forming a gently inclined frontal margin of approximately the same width as the fixed cheek, exclusive of the postero-lateral lobe. Facial sutures imperfectly preserved, the anterior section of the suture merging smoothly into the anterior extremity.

*Surface.*—Exterior surface minutely shagreened.

*Dimensions.*—Length of cranidium, 4.3 mm.; length of glabella, 3.0 mm.; width of glabella in front, 1.5 mm.; width of glabella at base, 2.1 mm.

*Type locality.*—(35f) Mount Stephen.

*Observations.*—This species is unlike *A. (?) unca* (fig. 1, pl. 13) and *A. stator* (Smithsonian Misc. Coll., Vol. 67, 1917, pl. 6, fig. 6) or any other species from the Lower Cambrian terrane.

*Formation and locality.*—Lower Cambrian: (35f) Mount Whyte formation; about 300 feet (95 m.) below the top of the Lower Cambrian in bluish-black and gray limestone (18 feet=5.5 m.), forming 6 of Mount Whyte formation; just above the tunnel, north shoulder of Mount Stephen, 3 miles (4.8 km.) east of Field, British Columbia, Canada.

**AGRAULOS (?) UNCA, new species**

Plate 13, figs. 1, 1a

Species known from cranidia.

*Cephalon.*—Cranidium very simple in outline, broadly and evenly rounded in front with two deltoid flanges at the base. Glabella three-quarters or more as long as the cranidium, subcylindrical, arcuate anteriorly; dorsal furrows linear, very faintly impressed, roughly parallel; glabellar furrows obsolete; occipital groove relatively broad but very shallow, uniform in depth between the dorsal furrows; occipital ring moderately broad, expanded medially, not nodose. Fixed cheeks and frontal limb and border not differentiated, together forming a rather broad and evenly declining brim around the glabella. Fixed cheeks rather narrow, the distance from the palpebral lobe to the dorsal furrow a little more than half the width of the medial portion of the glabella; postero-lateral lobe short and wide, obtusely cuneate at the distal extremity. Palpebral lobe very inconspicuous, defined merely by the outward arching in the facial sutures, very short and slightly anterior with respect to the glabella. Palpebral ridge faintly developed and not observable on most specimens. Frontal limb and border about one-third the length of the glabella, gently and evenly sloping, somewhat thickened toward the periphery. Facial sutures obtusely V-shaped, the anterior section feebly arcuate. Free cheeks not preserved.

*Surface.*—Exterior surface shagreened but not granulated.

*Dimensions.*—Length of cranidium, 2.5 mm.; width of cranidium at base, 3.0 mm.; length of glabella, 1.5 mm.; width of glabella in front, 1.9 mm.; width of glabella at base, 2.0 mm.

*Type locality.*—(61d) Mount Shaffer, British Columbia.

*Observations.*—*Agraulos ? unca* is exceedingly abundant at the type locality, but has been rarely observed elsewhere. The first comparison suggested is with *Ptychoparia thia*. It is a smoothed

out, rounded form, differing in the practical absence of glabellar furrows and palpebral ridges and in slight variations of the frontal limb and border. The two species are associated at locality 35f. The generic reference is doubtful, but with only the cranidia for study nothing better seems possible.

*Formation and locality.*—Lower Cambrian: Mount Whyte formation; (61d) southwest slope of Mount Shaffer on Canyon side, on trail to Lake McArthur, 5.5 miles (8.8 km.) south of Hector Station, on Canadian Pacific Railroad; and (35f) Mount Stephen section; about 300 feet (93.8 m.) below the top of the Lower Cambrian in bluish-black and gray limestone, just above the tunnel, north shoulder of Mount Stephen, 3 miles (4.8 km.) east of Field, both in British Columbia, Canada.

**OLENOPSIS CLEORA, new species**

Plate 13, figs. 3, 3a

Species known from imperfect cranidia.

*Cranidium.*—Cranidium elongate. Glabella only about three-fifths as long as the cranidium, rather strong, elevated along a low but sub-acute ridge which becomes obsolete at some little distance behind the anterior extremity; dorsal furrows quite broad and not very deeply impressed, gradually converging so that the width at the truncate anterior extremity is only about two-thirds of that at the base; glabellar furrows broad and shallow, obsolete upon the crest of the glabella, the posterior and medial pairs oblique, the anterior pair reduced to a couple of obscure lateral pits; occipital furrow broad and shallow, deepening a little toward the dorsal furrows; occipital ring low, flattened, moderately wide and carrying a small medial node. Fixed cheeks low and broad, the distance from the palpebral lobe to the dorsal furrow more than half the width of the medial portion of the glabella; postero-lateral lobe imperfectly preserved, narrow and probably petaloid at its extremity; posterior furrow very shallow, in line with the occipital ring. Palpebral lobe moderately elevated, about one-third as long as the glabella, asymmetrically arcuate, sub-medial in position with respect to the glabella. Palpebral ridge narrow, cordate, cutting somewhat obliquely across the fixed cheeks and intercepting the dorsal furrows at the origin of the anterior glabellar furrows. Frontal limb and border not sharply differentiated, the profile in front of the glabella gently concave. Frontal limb narrow, evenly declining medially, slightly convex laterally, cut off from the border by a shallow, ill-defined groove. Frontal border very wide,

expanded medially, and broadly concave. Outline of facial sutures and fixed cheeks not well preserved; anterior portion of facial suture apparently quite strongly arched.

*Surface*.—Exterior surface shagreened with an exceedingly fine and close granulation.

*Dimensions*.—Length of cranium, 16.0 mm.; length of glabella, 9.4 mm.; width of glabella in front, 4.6 mm.; width of glabella at base, 7.6 mm.

*Type locality*.—(62w) Above Gog Lake, Wonder Pass.

*Observations*.—There is a single pleural lobe of a thoracic segment associated with the cranidia which may perhaps be referable to this species. The segment is slender, not very deeply furrowed, and bent backward at an obtuse angle about halfway between the proximal and distal extremities.

The cranium of this species recalls that of *Olenopsis zoppi* by its broad frontal border, narrow frontal limb, elongate glabella and strong palpebral ridge. It is quite distinct from any associated form or forms from the same geological formation. It differs from *O. ? agnesensis*<sup>1</sup> in shorter frontal limb and broad frontal border (see figs. 5, 5a, pl. 13).

*Formation and locality*.—Lower Cambrian: Mount Whyte formation; (62w) oolitic limestone, about 400 feet (123 m.) below summit of ridge above Gog Lake, below Wonder Pass on Continental Divide, in British Columbia, 19 miles (30.4 km.) southwest of Banff; (57s) about 160 feet (49 m.) below the Middle Cambrian, in gray oolitic limestone, on Mount Bosworth, north of the Canadian Pacific Railway between Hector and Stephen; and (63i) thin layer of sandstone; between two eastern gullies on southern slope of Mount Bosworth, at about 6000-foot contour; 1 mile (1.6 km.) west-northwest of Stephen on the Canadian Pacific Railway, British Columbia.

#### OLENOPSIS CRITO, new species

Plate II, figs. 6, 6a-b

Species known from detached portions of the cephalon.

*Cephalon*.—Cranidium large, and moderately convex. Glabella three-fifths as long as the cranium, slender, subconical in outline, elevated along a rather prominent medial ridge which persists almost to the anterior extremity; dorsal furrows shallow but distinct, rounding sharply into the more shallow anterior furrow; anterior

<sup>1</sup> Smithsonian Misc. Coll., Vol. 57, 1912, p. 242, pl. 36, fig. 2.

extremity broadly rounded and half as wide as the base; posterior and medial pairs of glabellar furrows broad, deeply impressed, subequal and parallel to one another, extending obliquely backward and disappearing abruptly a little more than halfway up the lateral slope; third pair linear, transverse, shorter and much more shallow than those behind it; and an anterior pair indicated by slight indentations close to the dorsal furrow; occipital groove very shallow medially, similar in character laterally to the posterior glabellar furrows; occipital ring slightly expanded medially and apparently bearing near the posterior margin a very inconspicuous medial node. Fixed cheeks low, flattened, and very wide, the distance from the palpebral lobe to the dorsal furrow almost as great as the width of the medial portion of the glabella; postero-lateral lobe slender and elongate, probably acutely angulated at its distal extremity. Palpebral lobe imperfectly preserved, crescentic, approximately one-third the length of the glabella, the posterior end of the lobe on a line with the base of the posterior glabellar furrows. Palpebral ridge obscure, narrow, cordate, arching obliquely across the cheek and intercepting the dorsal furrows directly in front of the third pair of glabellar furrows. Frontal limb wide, very gently declining in front of the glabella, but rather steeply in front of the palpebral ridge. Frontal border also wide and gently concave, delimited from the limb by a low cord-like ridge. Facial sutures imperfectly preserved, posterior section extended outward at from  $10^{\circ}$  or  $15^{\circ}$  off the transverse line; anterior section also oblique and gently convex. Associated free cheek rather broad; inner portion of about the same width as the border, arching gently away from the palpebral lobe; border very wide, not conspicuously differentiated, produced posteriorly into moderately long, acutely tapering genal spines.

*Surface*.—Character of exterior surface not preserved.

*Dimensions*.—Length of a large cranium, 25.0 mm.; length of glabella, 15.0 mm.; width of glabella in front, 6.6 mm.; width of glabella at base, 13.0 mm.

*Type locality*.—(60e) Ptarmigan Pass.

*Observations*.—This is the largest species of the genus *Olenopsis* from the Mount Whyte formation. It compares in size with *O. americanus* of the Gordon shale,<sup>1</sup> but it differs from that species in the character of the frontal limb and border and elongate postero-lateral limb of the cranium. It occurs about 700 feet (213 m.) lower in

<sup>1</sup> See Smithsonian Misc. Coll., Vol. 67, 1917, p. 37, pl. 6, figs. 8, 8a-b.

the section than *O. americanus*. *O. crito* is unlike either *O. ? agnesensis*, *O. cleora*, or *O. leuka*, of the Mount Whyte formation.

*Formation and locality*.—Lower Cambrian: (60e) Mount Whyte formation; about 75 feet (22.8 m.) from the base of the formation; Ptarmigan Lake Pass at head of Corral Creek, 6 miles (9.6 km.) northeast of Laggan, Alberta, Canada.

**OLENOPSIS LEUKA**, new species

Plate 13, fig. 4

Species known from imperfect cranidia.

*Cranidium*.—Glabella approximately two-thirds the length of the cranidium, trapezoidal in outline, broadly convex; anterior extremity broadly rounded and almost three-fourths the width of the base; dorsal furrows linear, deeply impressed, evenly converging; glabellar furrows almost obsolete, owing probably to the absence of the outer test; traces of the posterior and medial pairs preserved in some individuals in the form of lateral pits, just within the dorsal furrows, the posterior pair somewhat elongated oblique to the axis; occipital groove rather narrow, partially dissecting the crest of the glabella and deepening toward the dorsal furrows; occipital ring of an elevation similar to that of the glabella, expanded medially; the median node if originally present has been destroyed. Fixed cheeks plump and wide, the distance from the palpebral lobe to the dorsal furrow approximately equal to the width of the medial portion of the glabella; postero-lateral lobe imperfectly preserved, rather narrow, moderately extended, obtusely tapering at the distal extremity; posterior groove quite deep, broadening away from the axis and cutting off an increasingly wider posterior margin. Palpebral lobe also imperfectly preserved but apparently low, short and submedial with respect to the glabella. Palpebral ridge obscure. Frontal limb narrow, flattened medially, merging into the fixed cheeks laterally. Frontal border defined by a shallow groove, thickened, upturned, and slightly expanded medially so that the width in front of the glabella is greater than that of the limb. Free cheeks unknown but probably narrow and produced posteriorly into slender spines. Other characters not preserved.

*Surface*.—Exterior surface unknown owing to the character of the matrix, a fine and very tough quartzitic sandstone.

*Dimensions*.—Length of cranidium, 7.5 mm.; length of glabella, 4.8 mm.; width of glabella in front, 2.3 mm.; width of glabella at base, 3.0 mm.

*Type locality*.—(58g) Mount Bosworth.

*Observations.*—The groove which separates the frontal limb from the border is obsolete medially, and the rim often has the appearance of being slightly produced posteriorly directly opposite the glabella. This character recalls *P. lux*, a smaller species with a more slender glabella, quite sharply rounded at the anterior extremity. The obscurity of the glabellar furrows is probably due in large measure to the character of the matrix, a rather firm quartzitic sandstone.

*Formation and locality.*—Lower Cambrian: Mount Whyte formation; (58g) about 200 feet (60 m.) below the top of the *Olenellus* zone in sandstones and shales, a few yards north of the Canadian Pacific Railroad track, midway between Stephen and Hector, on south slope of Mount Bosworth, British Columbia, Canada.

**PTYCHOPARIA ADINA, new species**

Plate 12, figs. 3, 3a-b

Species known from the cranidia and associated free cheeks, pygidia and disjointed thoracic segments.

*Cephalon.*—Cranidium small and approximately twice as broad at the base as it is long. Glabella quite strongly elevated along an obtuse median ridge, about three-quarters of the length of the cranidium, elongate-trapezoidal in outline, the squarely truncate anterior extremity only a little more than two-thirds as wide as the base; dorsal furrows linear, deeply impressed, evenly converging; anterior furrow not quite so deep as the lateral furrows; glabellar furrows very obscure, in most individuals practically obsolete, indicated in others by very feeble depressions toward the dorsal furrows, the posterior pair oblique, the medial and anterior pairs at right angles to the axis of the shield; occipital furrow moderately broad and quite deep, especially toward the dorsal furrows; occipital ring rather broad, expanded medially and bearing, midway between the margins, a small node. Fixed cheeks rising obliquely from the dorsal furrows, moderately wide, the distance from the palpebral lobe to the dorsal furrow approximately half the width of the medial portion of the glabella; postero-lateral lobe rather wide, extended laterally and obtusely angulated at the distal extremity; posterior furrow deeply channeled, cutting off an increasingly wider posterior margin away from the axis. Palpebral lobe not greatly elevated, rather short, contained a little less than three times in the length of the glabella, quite strongly crescentic, slightly anterior in position. Palpebral ridge obscure, somewhat oblique to the axis, intercepting the dorsal furrows a little behind the anterior extremity. Frontal

limb of moderate width, moderately convex. Frontal border cut off from the limb by a shallow linear groove, not so wide as the limb, flattened but not thickened. Facial sutures imperfectly preserved, apparently a rather symmetric W, the posterior section oblique, the base convex, the anterior section broadly arcuate. The associated free cheeks moderately wide, rather plump, the peripheral margin a flattened band cut off from the rest of the cheek by an ill-defined groove; outer margin abruptly constricted posteriorly and produced into very slender acutely tapering genal spines.

*Thorax*.—Thoracic segments rather narrow, deeply sulcated medially, slender and acutely falcate at their distal extremities.

*Pygidium*.—Associated pygidium comparable in dimensions to the cephalon, rudely lenticular in outline. Axial lobe broad, strongly convex, obtusely truncate at the posterior extremity; axial annulations distinct anteriorly, obscure posteriorly, indicating 4 component segments and a terminal section. Pleural lobes of approximately the same width anteriorly as the axial, wedging out posteriorly; pleural furrows rudely parallel to the anterior margin, increasingly shallow toward the posterior extremity. Peripheral rim narrow, smooth, defined only by the abrupt disappearance of the pleural grooving. Posterior extremity very broadly rounded or obtusely truncate.

*Surface*.—Exterior surface microscopically granulated.

*Dimensions*.—The largest cranidium in the collection has a length of 8 mm., but the average size is 4 mm. or less in length.

*Type locality*.—(57q) Mount Bosworth, British Columbia.

*Observations*.—The limestone at the type locality is densely packed with the cranidia, free cheeks, and less frequently the thoracic segments and pygidia of this species.

*P. lux*, of the Mount Whyte formation, has a more slender glabella, which tapers to a rounded anterior extremity instead of being squarely truncate as in *P. adina*; furthermore, the fixed cheeks are wider in *lux* than in *adina*, the palpebral lobe is not placed so far forward, the frontal limb is narrower medially, and the frontal border is expanded and tends to be somewhat produced posteriorly directly opposite the anterior extremity of the glabella. *P. adina* is quite distinct from *P. thia* and *Agraulos ? unca*.

*Formation and locality*.—Lower Cambrian: (57q) Mount Whyte formation ? (Mount Bosworth section); drift block supposed to be from about 200 feet (61.2 m.) below the top of the Lower Cambrian in bluish-gray limestone (60 feet) forming 16c in Mount Whyte

formation, slopes of Mount Bosworth, a little north of the Canadian Pacific Railway track, between Stephen and Hector, British Columbia, Canada.

**PTYCHOPARIA CARINA**, new species

Plate 13, figs. 6, 6a

Species known from a single imperfect cranidium.

*Cranidium*.—Cranidium apparently short and broad. Glabella not far from three-quarters the length of the cranidium, moderately broad and moderately elevated along an obtuse medial ridge which becomes obsolete at some little distance behind the anterior extremity; dorsal furrows rather shallow; anterior extremity of the glabella more strongly rounded than the frontal border and only about two-thirds as wide as the base; glabellar furrows conspicuously deep, the posterior pair much more produced than the medial and more strongly oblique; medial pair short, but deeply gouged toward the dorsal furrows; anterior pair reduced to a couple of obscure lateral pits; character of occipital furrow and ring not preserved. Fixed cheeks low and broad, the distance from the palpebral lobe to the dorsal furrow more than half the width of the medial portion of the glabella; postero-lateral lobe imperfectly preserved but apparently slender and elongated; posterior groove rather broad and moderately deep. Palpebral lobe not preserved but probably short, inconspicuous and placed far back, in line with either the posterior glabellar furrows or the posterior lobe of the glabella. Palpebral ridge narrow, cordate, arching obliquely across the fixed cheeks and intercepting the dorsal furrows at some little distance behind the anterior extremity. Frontal limb flattened, very narrow medially. Frontal border a rather broad fillet, cut off from the limb by a sharply defined groove, and a little wider medially than the limb. Other characters not preserved.

*Surface*.—Exterior surface shagreened with a fine and close granulation; a few coarser macroscopic granules scattered sparsely over the surface of the cranidium.

*Dimensions*.—Length of cranidium,  $13.2 \pm$  mm.; length of glabella,  $9.5 \pm$  mm.; width of glabella in front, 4.5 mm.; width of glabella at base, 6.8 mm.

*Type locality*.—(35m) 3 miles (4.8 km.) southwest of head of Lake Louise, Alberta.

*Observations*.—This species has such a thickly granulated and pustulose surface and such a strong frontal border that it is readily distinguished from other species of this horizon and fauna. The

granulation recalls that of *P. permulta*, a species occurring in the *Albertella* shale about 700 feet (213.4 m.) higher in the section.

*Formation and locality.*—Lower Cambrian: (35m) Mount Whyte formation; 3 miles (4.8 km.) southwest of the head of Lake Louise, on east slope of Mount Whyte, Alberta, Canada.

PTYCHOPARIA (?) CERCOPS, new species

Plate 12, figs. 1, 1a-d

Species known from imperfect cranidia, free cheeks, and pygidia.

*Cephalon.*—Cephalon not found entire. Cranidium large, feebly contoured. Glabella long relatively, almost four-fifths the length of the cranidium, slightly elevated along a narrow but rather distinct ridge which becomes obsolete at some little distance behind the anterior extremity; dorsal furrows shallow, gradually converging toward the broadly arcuate anterior extremity; glabellar furrows broad and exceedingly obscure, the posterior pair oblique, the medial pair transverse to the axis, the anterior pair probably very short, and parallel to the medial furrows, but in the majority of individuals entirely obsolete; occipital furrow very broad and very shallow especially upon the crest of the glabella; occipital ring low and flattened, expanded medially, bearing near the posterior margin a small but prominent node. Fixed cheeks low, narrow, the distance from the palpebral lobe to the dorsal furrow a little less than half the width of the medial portion of the glabella; postero-lateral lobe wide, cuneiform, obtusely angulated at the distal extremity, not quite twice as long as its greatest width; posterior groove broad and shallow, narrowest and deepest toward the dorsal furrow, its proximal extremity in line with the occipital ring. Palpebral lobe very inconspicuous, very short, only about one-fifth as long as the glabella, scarcely at all elevated, and placed far forward opposite the anterior glabellar furrows. Palpebral ridge not defined, obscurely suggested. Frontal limb and border slightly differentiated from one another, the profile between the anterior extremity of the glabella and the outer margin gently concave. Facial sutures rudely and asymmetrically V-shaped, the posterior arm oblique, the anterior arm broadly and quite strongly arched. Associated free cheeks low and broad, gently and smoothly convex, bordered by a wide and ill-defined band, and without traces of genal spines.

*Thorax.*—Associated thoracic segments of moderate width. Axial lobe not preserved. Pleural segments flexuous, posteriorly directed and acutely falcate at their distal extremities; pleural furrows

obsolete toward the axis, very deeply channeled medially, gradually wedging out distally; anterior margin a little narrower and more sharply elevated than the posterior.

*Pygidium*.—Associated pygidia twice as broad as long. Axial lobe broadly but not very strongly arched, subcylindrical, obtusely tapering posteriorly, rather sharply annulated even to the posterior extremity, including, apparently, 4 component segments. Pleural lobes differentiated from the axial merely by the contour, not cut off by incised furrows; annular ridges of the axial lobe persistent across the pleura, for the most part without change in direction or character, the posterior ridges, however, obsolete upon the pleura. Peripheral rim narrow, flattened, reduced to a mere thread posteriorly, widening gradually toward the thorax. Posterior extremity sharply rounded.

*Surface*.—Exterior surface shagreened but not distinctly granulated.

*Dimensions*.—Length of a cranidium, 20.4 mm.; length of glabella, 16.1 mm.; width of base of glabella, 12.5 mm.; width of front of glabella, 6.3 mm.

*Type locality*.—(63c) Ptarmigan Peak.

*Observations*.—The cranidium of *P. cercops* Walcott is relatively large and relatively long, and the relief upon the cranidium is conspicuously low. It is quite abundant at the type locality, but is not found commonly elsewhere.

*Formation and locality*.—Lower Cambrian: Mount Whyte formation; (63c) 85 feet (26 m.) up in alternating oolitic limestone and thin-bedded compact sandstones forming 1 of section, and (63a) oolitic limestone about 130 feet (40 m.) above arenaceous shaly beds; both from east base of Ptarmigan Peak, 5.5 miles (8.8 km.) in an air line northeast of Lake Louise station on the Canadian Pacific Railway, Alberta, Canada.

Small cranidia in a compact shaly sandstone matrix from the Mount Whyte horizon of Castle Mountain appear to be identical with cranidia of similar size of this species. Locality 58t, Lower Cambrian: Mount Whyte formation; sandy shale about 150 feet (45.7 m.) below the Middle Cambrian, just below the big cliff on the east shoulder of Castle Mountain, north of the Canadian Pacific Railway, Alberta.

Somewhat similar cranidia occur in the oolitic limestone of Ross Mountain, but they have a slightly more distinct glabellum and are

not quite so much smoothed out. Locality 63k, Lower Cambrian: Mount Whyte formation; above and southeast of Ross Lake, 1 mile (1.6 km.) south of Stephen, Canadian Pacific Railway, on Continental Divide, British Columbia, Canada.

**PTYCHOPARIA (?) CLEADAS, new species**

Plate 12, fig. 2

Species known from cranidia.

*Cephalon*.—Cranidium minute, angular in outline, narrow and truncate in front, relatively wide at the base. Glabella long, approximately three-fourths the length of the cranidium, quite strongly elevated along the sharply rounded medial ridge, trapezoidal in outline; dorsal furrows linear, incised, converging with a moderate degree of rapidity toward the squarely truncate anterior extremity; glabellar furrows rather obscure, the posterior pair inclined to the median axis at an angle of about  $45^\circ$ , not persistent across the crest of the glabella, the medial pair a little shorter and less oblique, and the anterior pair much reduced and in some individuals entirely obsolete; occipital groove narrow and deep, uniform in character between the dorsal furrows; occipital ring flattened, constricted laterally, widely expanded medially and bearing near the posterior margin a small medial node. Fixed cheeks wide and evenly declining from the dorsal furrows; postero-lateral lobe very wide, deltoid in outline, probably obtusely angulated at its distal extremity; posterior furrow narrow but deeply incised, cutting off an increasingly wider posterior margin away from the axis. Palpebral lobe imperfectly preserved but apparently very short, inconspicuous, and placed far forward opposite the medial glabellar furrows. Palpebral ridge very narrow but usually distinct, arching across the fixed cheeks and intercepting the dorsal furrows directly behind the anterior extremity of the glabella. Frontal limb narrow, flattened. Frontal border a little wider than the limb, thickened, cordate, and somewhat expanded medially. Facial sutures very imperfectly preserved, the posterior section very long relatively and probably oblique, the anterior arm short and probably arcuate. Other characters not preserved.

*Surface*.—Exterior surface felt-like.

*Dimensions*.—Length of cranidium, 2.0 mm.; length of glabella, 1.5 mm.; width of cranidium at base,  $3.0 \pm$  mm.

*Type locality*.—(57s) Mount Bosworth.

*Observations.*—*P.* (?) *cleadas* Walcott may be readily separated from other species of the genus by its very small size and angular outline, its sharply defined trapezoidal glabella, its very small anterior eye placed far forward and the consequently very wide posterior lobe, its very narrow limb and almost equally narrow cordate border roughly parallel to the base of the cranidium.

These carbon-black cranidia, though so minute, show up quite well in the gray limestone of the type locality.

The specimens from the arenaceous shale at Ptarmigan Pass (Locality 60e) are in the form of casts and do not show the glabellar furrows, but this appears to result from the condition of preservation. The glabella is also relatively shorter than that of the specimen illustrated but not shorter than some of those in the same hand specimen of limestone containing the type specimen.

*Formation and locality.*—Lower Cambrian: Mount Whyte formation; (57s) about 160 feet (49 m.) below the Middle Cambrian, near the base of the gray oolitic limestone, on Mount Bosworth, north of the Canadian Pacific Railway between Hector and Stephen, on the Continental Divide between British Columbia and Alberta; (58u) drift block supposed to have come from about 240 feet (73.8 m.) below the top of the Lower Cambrian in limestone interbedded in sandstone (31 feet); slopes of Mount Bosworth, a little north of the Canadian Pacific Railway track, between Stephen and Hector, British Columbia; also (60e) about 75 feet (22.8 m.) from the base of the Mount Whyte formation; Ptarmigan Lake Pass at head of Corral Creek, 6 miles (9.6 km.) northeast of Laggan, Alberta, Canada.

**PTYCHOPARIA CLEON, new species**

Plate 12, fig. 10

Species known from an imperfect cranidium.

*Cephalon.*—Cranidium small and moderately convex. Glabella low, elevated along an obscure median ridge which is moderately elevated posteriorly and increasingly lower anteriorly; dorsal furrows linear, rather shallow, converging so that the width of the truncate anterior extremity is about three-fifths of that at the base; glabellar furrows obscure, the posterior and medial pairs subparallel, disappearing about halfway up to the median line; anterior pair obsolete; occipital groove rather shallow, deepening slightly toward the dorsal furrows; occipital ring imperfectly preserved. Fixed cheeks low, wide, the distance from the palpebral lobe to the dorsal furrow more than half the width of the medial portion of the

glabella; postero-lateral lobe imperfectly preserved but probably strong and moderately extended; posterior groove very narrow toward the axis, terminating opposite the occipital ring, broader and more shallow away from the axis, and cutting off an increasingly wider posterior margin. Palpebral lobe narrow, crescentic, contained about three times in the length of the glabella, in line with the posterior glabellar furrows. Palpebral ridge oblique, defined only by the angulation of the cheek, not outlined by a raised cord or liration. Frontal limb rather narrow in front of the glabella and flattened, rather steeply declining in front of the palpebral ridge. Frontal border narrow, thickened, the medial portion posteriorly produced and acutely angulated. Facial sutures imperfectly preserved; anterior section apparently very strongly convex.

*Surface*.—Exterior surface microscopically shagreened. Venation upon the frontal limb very fine.

*Dimensions*.—Length of cranium, 3.5 mm.; length of glabella, 2.5 mm.

*Type locality*.—(35f) Mount Stephen.

*Observations*.—The cranium of this species is much like that of *Ptychoparia thia* except that the frontal limb is longer in front of the glabella and there is a swelling or elongate tubercle on the frontal rim opposite the glabella. The species is known only by a single specimen of the cranium from the limestone at the type locality (35f).

*Formation and locality*.—Lower Cambrian: (35f) Mount Whyte formation; about 300 feet (95 m.) below the top of the Lower Cambrian in bluish-black and gray limestone (18 feet = 5.5 m.) forming 6 of Mount Whyte formation; just above the tunnel, north shoulder of Mount Stephen, 3 miles (4.8 km.) east of Field, British Columbia, Canada.

#### PTYCHOPARIA CLUSIA, new species

Plate 11, figs. 3, 3a

Species known from imperfect crania.

*Cephalon*.—Glabella a little more than two-thirds as long as the cranium, quite strongly elevated along a subacute medial ridge which disappears gradually toward the front; outline trapezoidal, the broadly rounded anterior extremity not more than half as broad as the base; dorsal furrows rather wide, deeply impressed, converging quite rapidly anteriorly and rounding sharply into the more shallow, transverse anterior furrow; glabellar furrows also broad

and deep, though not persistent across the crest; posterior pair inclined to the axis of the shield at an angle of a little more than  $45^\circ$ , almost completely isolating the tumid posterior lobe; medial pair neither so broad nor so deep as the posterior and nearly at right angles to the axis; anterior pair a little shorter than the medial, slightly inclined toward the front and placed nearer to the medial pair than to the anterior furrow; occipital groove broad and deep, completely dissecting the crest of the glabella, very slightly sinuous; occipital ring rather narrow, expanded medially, obtusely angulated at the medial posterior margin, and bearing a rather prominent medial node. Fixed cheeks plump and quite wide, the distance from the palpebral lobe to the dorsal furrow a little more than half the width of the medial portion of the glabella; postero-lateral lobe narrow and probably extended laterally; posterior furrow conspicuously broad and deep, its inner terminus in line with both the occipital furrow and ring; posterior margin narrow and sharply elevated. Palpebral lobe short, narrow, crescentic, set opposite the lobe between the posterior and medial furrows. Palpebral ridge rather prominent, cordate, arching across the fixed cheeks and intercepting the dorsal furrows directly in front of the anterior glabellar furrows. Frontal limb rather narrow, inflated laterally, gently declining medially. Frontal border wider medially than the limb, sharply upturned. Facial sutures imperfectly preserved.

*Surface*.—Exterior surface very finely and closely granulated or roughened by an irregular pitting with broken, depressed ridges that give the effect of obscure granulation.

*Dimensions*.—Length of cranidium, 7.5 mm.; length of glabella, 5.25 mm.; width of glabella in front, 2.0 mm.; width of glabella at base, 4.2 mm.

*Type locality*.—(58k) Mount Stephen.

*Observations*.—The glabella of this species recalls that of *P. gogensis* and less so that of *P. pia* (pl. 12, figs. 4 and 8). The frontal border is quite unlike that of either of the two species.

*Formation and locality*.—Lower Cambrian: (58k) Mount Whyte formation; just above the tunnel, north shoulder of Mount Stephen, 3 miles (4.8 km.) east of Field, British Columbia, Canada.

#### PTYCHOPARIA COSSUS, new species.

Plate 11, figs. 5, 5a

Species known from an imperfect cranidium.

*Cephalon*.—Cranidium small, moderately convex. Glabella a little more than three-fourths as long as the cranidium, moderately

elevated along an obtuse median ridge, relatively broad; dorsal furrows well rounded and quite deep, converging so that the rounded truncate anterior extremity is only a little more than two-thirds as wide as the base; anterior furrow shallow and not sharply defined; glabellar furrows rather obscure and not persistent to the crest of the glabella, the posterior pair oblique, the medial pair more nearly horizontal, the anterior pair slightly inclined toward the anterior extremity; occipital furrow sinuous, arched forward upon the crest, deepening toward the dorsal furrows; occipital ring not preserved. Fixed cheek low, flattened, the distance from the palpebral lobe to the dorsal furrow a little more than half the width of the glabella; postero-lateral lobe imperfectly preserved, narrow and elongate; posterior groove narrow but well rounded, in line with the occipital ring. Palpebral lobe very short, not very prominent, in line with the posterior glabellar furrows. Palpebral ridge low, cordate, cutting obliquely across from the palpebral lobe and intercepting the dorsal furrows at the origin of the anterior glabellar furrows. Frontal limb narrow and flattened in front of the glabella. Frontal border wide, slightly convex, somewhat thickened, the inner margin almost at right angles to the axis, the outer margin strongly arcuate. Facial sutures imperfectly preserved.

*Surface*.—Exterior surface minutely shagreened.

*Dimensions*.—Length of cranidium, 8.0 mm.; length of glabella, 5.5 mm.

*Type locality*.—(61a) Yoho Canyon.

*Observations*.—The glabella of this species recalls that of *P. cuneas*, but the frontal limb differs in being narrower and in having a gently convex surface.

*Formation and locality*.—Lower Cambrian: (61a) Mount Whyte formation; gray oolitic siliceous limestone; Yoho Canyon, 1.5 miles (2.4 km.) above mouth of Yoho River and about 5.5 miles (8.8 km.) from Field on Canadian Pacific Railway, British Columbia, Canada.

#### PTYCHOPARIA CUNEAS, new species

Plate II, figs. 4, 4a

Species known from an imperfect cranidium.

*Cephalon*.—Glabella relatively short, only about two-thirds as long as the cranidium, moderately convex, trapezoidal in outline; dorsal furrows moderately deep, rounding rather sharply into the shallow groove which outlines the truncated anterior extremity. Glabellar furrows imperfect; posterior pair rather broad, shallow and ex-

tending obliquely inward to a low, strong medial ridge that continues nearly to the front of the glabella; the medial and anterior pairs transverse; occipital groove broad and shallow upon the summit of the glabella, narrow and deep toward the dorsal furrows; occipital ring moderately elevated and expanded medially, bearing a small but rather sharp medial node. Fixed cheeks slightly convex, the distance from the palpebral lobe to the dorsal furrow approximately half the width of the medial portion of the glabella; postero-lateral lobe rather narrow, posterior groove narrow, deep, its axial terminus in line with the occipital ring. Palpebral lobe short, crescentic, not very prominent, placed rather far back opposite the posterior glabellar furrows. Palpebral ridge low and ill-defined, it arches obliquely across the fixed cheek and intercepts the dorsal furrow a little behind the anterior extremity. Frontal limb narrow, flattened in front and merging into the fixed cheeks laterally. Frontal border slightly elevated, flattened, and with a shallow, transverse median depression, slightly expanded both along the outer and the inner margin, wider than the frontal limb and cut off from it by a shallow sulcus. Facial sutures imperfectly preserved; anterior section gently arcuate.

*Surface*.—Exterior surface exhibiting a felt-like texture.

*Dimensions*.—Length of cranidium, 8.0 mm.; length of glabella, 5.1 mm.; width of glabella in front, 2.7 mm.; width of glabella at base, 4.5 mm.

*Type locality*.—(35f) Mount Stephen.

*Observations*.—The broad, short glabella and broad frontal border of this species serve to distinguish it from other species of *Ptychoparia* from the Mount Whyte formation. The frontal border has a slight resemblance to that of *P. gogensis* (pl. 12, fig. 4). The short, broad glabella recalls that of some undescribed species from the Lower Cambrian of the St. Lawrence Valley.

*Formation and locality*.—Lower Cambrian: (35f) Mount Whyte formation (Mount Stephen section); about 300 feet (93.8 m.) below the top of the Lower Cambrian in bluish-black and gray limestone, just above the tunnel, north shoulder of Mount Stephen, 3 miles (4.8 km.) east of Field, British Columbia, Canada.

#### PTYCHOPARIA GOGENSIS, new species

Plate 12, figs. 4, 4a

Species known from imperfect cranidia.

*Cranidium*.—Cranidium large and relatively broad, the maximum width exclusive of the free cheeks more than double the length;

glabella prominent, nearly three-fourths as long as the cranidium, conspicuously elevated along an obtuse medial ridge; dorsal furrows broad and deeply channeled, slowly converging toward the front; anterior extremity of glabella approximately two-thirds as wide as the base, obtusely truncate, and outlined by a shallow groove; glabellar furrows deep on the sides of the glabella but entirely obsolete upon the crest; posterior pair broad and deep, obliquely arcuate; medial pair not so deep as the posterior; anterior pair obscure, set very close to the medial pair; lobe between the occipital groove and the posterior pair of furrows quite strongly elevated, that between the posterior and medial pairs also rather prominent; occipital furrow broad, and quite deep, especially towards the dorsal furrows; occipital ring narrow, somewhat expanded medially; a median node is suggested by what appears to have been a broken-off base of a tubercle. Fixed cheeks rising abruptly from the dorsal furrows, then arching gently to the palpebral lobe, the distance from the palpebral lobe to the dorsal furrow more than half the width of the medial portion of the glabella; postero-lateral lobe slender and petaloid; posterior groove deep, broadening away from the axis, nearly in line with the occipital furrow. Palpebral lobe rather short, crescentic, moderately prominent, and placed opposite the posterior glabellar furrows. Palpebral ridge obtuse, cutting somewhat obliquely across the fixed cheeks and intercepting the dorsal furrows near the origin of the anterior glabellar furrows. Frontal limb very narrow and quite steeply declining medially, broadly inflated laterally. Frontal border separated by a shallow sulcus, nearly flat at the center and slightly concave at the sides posteriorly produced opposite the glabella and obtusely angulated.

*Surface*.—Exterior surface, imperfectly preserved, but apparently shagreened by a fine granulation.

*Dimensions*.—Length of cranidium, 14.0 mm.; width of cranidium at base,  $30.0 \pm$  mm.; length of glabella, 10.0 mm.; width of glabella in front, 5.5 mm.; width of glabella at base, 8.5 mm.

*Type locality*.—(62w) Above Gog Lake, Wonder Pass.

*Observations*.—The more widely distributed *P. pia* is much smaller and not so coarse as *P. gogensis*, but it has much the same general appearance. The glabella of *P. gogensis* is more elevated and proportionally broader, the dorsal furrows are more deeply channeled, the glabellar furrows are also deeper, and the posterior and medial glabellar lobes consequently higher. The relative width of the fixed cheeks is approximately the same in both species, but they are lower

in *P. pia*. There is a further resemblance in the outline of the frontal rim, but in *P. pia* the rim is thickened and flattened, while in *P. gogensis* it is not thickened and it is concave at the sides.

*Formation and locality.*—Lower Cambrian: Mount Whyte formation; (62w) oolitic limestone, about 400 feet (123 m.) below summit of ridge above Gog Lake below Wonder Pass on Continental Divide, in British Columbia, 19 miles (30.4 km.) southwest of Banff, Alberta.

**PTYCHOPARIA LUX, new species**

Plate 12, fig. 5

Species known from cranidia.

*Cephalon.*—Relative proportions of cephalon varying quite widely, the length in the majority of individuals more than half the greatest width. Glabella short and rather slender, quite strongly elevated along an obtuse medial ridge which disappears a little behind the anterior extremity; dorsal furrows quite deeply impressed, converging with a moderate degree of rapidity toward the arcuate anterior extremity; curvature of front of glabella usually a little greater than that of the frontal margin; width of front of glabella only about half the width of the base of the glabella; glabellar furrows exceedingly obscure and in most individuals entirely obsolete, sometimes indicated by very feeble lateral depressions just within the dorsal furrows; occipital groove narrow, persistent across the crest of the glabella but deepening toward the dorsal furrows; occipital ring moderately broad, flattened, expanded medially, and bearing near the posterior margin a small node. Fixed cheeks broad and plump, the width from the palpebral lobe to the dorsal furrow equal, approximately, to the width of the medial portion of the glabella; postero-lateral lobe very narrow, moderately extended, petaloid at the distal extremity; posterior groove in line with the occipital ring, widening away from the axis and cutting off an increasingly wider posterior margin. Palpebral lobe not very prominent, contained about two and one-half times in the length of the glabella, feebly arcuate, sub-medial with respect to the glabella. Palpebral ridge narrow, and very obscure, curving obliquely across the fixed cheeks and intercepting the dorsal furrows a little behind the anterior extremity. Frontal limb narrow, flattened medially, feebly inflated laterally. Frontal border crescentic, wider medially than the frontal limb, and often somewhat produced posteriorly, cut off from the limb by a groove rather sharply impressed laterally but often very obscure medially. Facial sutures imperfectly preserved; posterior section

rudely transverse to the axis, medial section relatively short, anterior section strongly convex.

Other characters of the cephalon and the thorax not preserved.

*Surface*.—Exterior surface shagreened with a microscopically fine but rather sharp granulation.

*Dimensions*.—Length of cranidium, 4.0 mm.; length of glabella, 3.0 mm.; width of glabella in front, 1.5 mm.; width of glabella at base, 2.0 mm.

*Type locality*.—(61d) Mount Shaffer.

*Observations*.—See observations under *P. adina*.

*P. lux* is very common at the type locality.

*Formation and locality*.—Lower Cambrian: Mount Whyte formation; (61d) southwest slope of Mount Shaffer on Canyon side, on trail to Lake McArthur, 5.5 miles (8.8 km.) south of Hector Station, on Canadian Pacific Railroad, British Columbia, Canada.

#### PTYCHOPARIA PEROLA, new species

Plate 12, figs. 7, 7a

*Dorsal shield*.—Dorsal shield small, elongate-oval in outline, flattened in the shale but probably quite strongly contoured originally. Axial lobe rather slender, arched well above the pleura and cut off from them by rather deep furrows.

*Cephalon*.—Cephalon about one-third as long as the dorsal shield, rudely semicircular in outline. Glabella of moderate dimensions, subrectangular or trapezoidal in outline, that of the type a little broader relatively than in the average individual; medial ridge low and obtuse, dorsal furrows deeply impressed, evenly converging toward the squarely truncate anterior extremity; glabellar furrows quite broad and moderately deep, but not persistent across the crest; posterior pair somewhat oblique; medial and anterior pairs almost at right angles to the axis, the anterior pair reduced, however, to nothing more than a couple of lateral pits; occipital groove partially dissecting the crest of the glabella, deeply impressed toward the dorsal furrows; occipital ring narrow, expanding slightly medially, and bearing near the posterior margin a small sharp node. Fixed cheeks low and moderately wide, the distance from the palpebral lobe to the dorsal furrow a half or a little more than half as wide as the medial portion of the glabella; postero-lateral lobe rather short, broad, and trigonal, quite acutely angulated at its distal extremity; posterior furrow broad and quite deep, almost in line with the occipital furrow. Palpebral lobe inconspicuous, almost straight, very

slightly elevated, and less than one-third as long as the glabella including the occipital ring, placed rather far forward, opposite the medial glabellar furrows. Palpebral ridge narrow, sharply defined, cutting across the fixed cheeks almost at right angles to the axis and intercepting the dorsal furrows a little behind the anterior extremity of the glabella. Frontal limb rather narrow, slightly inflated, cut off from the flattened frontal border by a shallow groove parallel to the anterior extremity of the glabella. Frontal border thus forming a chord about two-thirds the length of the base of the cranium, the medial portion of which is of approximately the same width as the medial portion of the frontal limb. Facial sutures interrupted medially by the small palpebral lobes, the posterior arm oblique, the anterior arm broadly convex. Free cheeks narrow, smoothly convex, bordered by a flattened band produced posteriorly into short, acutely tapering genal spines.

*Thorax*.—Thoracic segments 15 in number. Axial lobe quite strongly convex, very strongly annulated. Pleural segments compactly arranged, the flattened portion between the obtuse geniculation and the axial furrows not quite so wide, as a rule, as the axial lobe. Pleural furrows almost as wide as the including segment excepting toward the axis where they are narrower and anterior in position; anterior margin of the segment a little more sharply elevated than the posterior; extremities of segments imperfectly preserved but probably attenuated and acutely falcate.

*Pygidium*.—Associated pygidium small, short and broadly lenticular in outline. Axial lobe rather coarse, subcylindrical, tapering slightly toward the obtuse posterior extremity; annulations distinct, indicating possibly two component segments and a terminal section. Pleural lobes drooping, of approximately the same width anteriorly as the axial lobe, obscurely furrowed with one or two shallow grooves, parallel to the arcuate anterior margin. Peripheral rim narrow, flattened, obscurely defined; periphery broadly rounded, often obtusely truncate at the posterior extremity.

*Surface*.—Exterior surface shagreened but apparently not granulated.

*Dimensions*.—Length,  $17.0 \pm$  mm.; greatest width,  $10.0 \pm$  mm.

*Type locality*.—(35m) Mount Whyte.

*Observations*.—This is one of the relatively narrow, elongate forms of the genus that suggests *P. cordillerae* of the Middle Cambrian. It differs from the latter species in having a stronger frontal border on the cephalon, less elongate glabella, narrower frontal limb,

15 thoracic segments instead of 18 or 19, and a narrower pleural thoracic lobe. It is most nearly related to *P. candace*<sup>1</sup> of the Middle Cambrian *Albertella* fauna of Gordon Creek, Montana, from which it differs in having a narrower frontal limb in front of the glabella and a less elongate glabella; otherwise the two species closely resemble each other.

All the specimens of *P. perola* are compressed in a hard siliceous, finely arenaceous shale from which the test of the trilobite has been removed, and the replacement shows only a finely roughened surface that may be a reproduction of the original surface, or it may be roughened by the fine-grained matrix having been impressed in the original test.

The largest dorsal shield has a length of 20 mm. The proportions of the various parts are well shown by figure 7, the original of which has a length of 16 mm. The relatively large cranidium, elongate thorax, and very small pygidium are finely brought out in this figure.

*Formation and locality.*—Lower Cambrian: (35m) Mount Whyte formation; Lake Agnes shale, 3 miles (4.8 km.) southwest of the head of Lake Louise on the east slope of Mount Whyte; also (35e) amphitheater between Popes Peak and Mount Whyte, southwest of Lake Agnes, and 3 miles (4.8 km.) southwest of the head of Lake Louise Station on the Canadian Pacific Railroad, both in western Alberta, Canada.

#### PTYCHOPARIA PIA, new species

Plate 12, fig. 8

Species known from imperfect cranidia and associated thoracic segments.

*Cranidium.*—Cranidium relatively short and broad, dissected by the dorsal furrows into three subequal areas. Glabella rather large relatively, quite prominently elevated along a very obtuse medial ridge which disappears a little behind the anterior extremity; dorsal furrows deeply channeled, converging to a slight degree toward the rounded truncate anterior extremity, so that the front of the glabella is not very much more than two-thirds as wide as the base. Glabellar furrows broad and, toward the dorsal furrows, moderately deep, obsolete, however, upon the summit of the glabella; posterior pair oblique, the medial pair a little shorter and at right angles to the axis, the anterior pair still shorter and rather obscure, transverse or inclined slightly toward the front; posterior and medial glabellar

<sup>1</sup> See pl. 6, fig. 3, Smithsonian Misc. Coll., Vol. 67, 1917.

lobes quite prominently elevated; occipital furrow broad, partially dissecting the crest of the glabella, deepening toward the dorsal furrows; occipital ring rather narrow, expanding medially and bearing on well-preserved individuals a small median node. Fixed cheeks wide and plump, the distance from the palpebral lobe to the dorsal furrow only a little less than the width of the medial portion of the glabella; postero-lateral lobe rather narrow and extended, somewhat falcate at its extremity; posterior furrow deeply concave, narrow toward the axis, broadening away from it, and cutting off an increasingly wider posterior margin. Palpebral lobe short, crescentic, quite prominently elevated, submedial or slightly anterior in position, with respect to the glabella. Palpebral ridge obscure, extending obliquely across the fixed cheeks and intercepting the dorsal furrows near the margin of the anterior glabellar furrows. Frontal limb narrow, evenly declining, in some individuals obscurely truncated in front of the glabella. Frontal border cut off from the limb by a shallow, ill-defined groove, narrow laterally but widening medially and slightly produced posteriorly so that in front of the glabella the border is wider than the limb. Facial sutures imperfectly preserved, the posterior section somewhat flexuous, the anterior section broadly arcuate. Associated free cheeks low and broad, bordered by a thickened cordate rim, cut off from the rest of the cheek by a shallow groove, and produced posteriorly into rather short, acutely tapering spines.

*Thorax*.—Associated thoracic segments rather wide, deeply channeled, the anterior margin undercut; extremities falcate.

*Surface*.—Exterior surface crowded with an irregular, very fine granulation which on slightly worn individuals assumes a felt-like aspect.

*Dimensions*.—Length of cranium, 14.2 mm.; length of glabella, 9.8 mm.; width of glabella in front, 5.0 mm.; width of glabella at base, 8.5 mm.

*Type locality*.—(35f) Mount Stephen.

*Observations*.—*P. pia* Walcott is, perhaps, the most widely distributed member of the genus in the Mount Whyte formation. There are no described forms which approach close to *P. pia*, though *P. gogensis* and *P. skapta* resemble it in general outline and contour, and in the relative proportions of the glabella. *P. gogensis*, however, is almost double the dimensions of *P. pia*, the glabella is more convex, the dorsal and glabellar furrows are deeper, the fixed cheeks higher, and the frontal rim upturned but not thickened as in

*pia*. *P. skapta*, on the other hand, is only about half the size of *pia*, and the frontal rim is very much narrower relatively and much more thickened than in *pia*.

*Formation and locality*.—Lower Cambrian: (35f) Mount Whyte formation (Mount Stephen section); about 300 feet (93.8 m.) below the top of the Lower Cambrian in bluish-black and gray limestone; just above the tunnel, north shoulder of Mount Stephen, 3 miles (4.8 km.) east of Field; (35h) about 375 feet (114 m.) below the Middle Cambrian, in shales of the Mount Whyte formation, on Mount Bosworth, north of the Canadian Pacific Railway between Hector and Stephen, on the Continental Divide between British Columbia and Alberta; (63k) north spur of Mount Whyte, above and southeast of Ross Lake, 1 mile (1.6 km.) south of Stephen, Canadian Pacific Railway on Continental Divide; and (57r) just above the tunnel, north shoulder of Mount Stephen, 3 miles (4.8 km.) east of Field.

A cranidium that may belong with this species occurs in the limestone of (3) of the Mount Stephen section, about 180 feet (54.8 m.) above the horizon of the type specimen, which occurs in (4) of that section:<sup>1</sup> Lower Cambrian: (57e) Mount Whyte formation; about 115 feet (35 m.) below the top of the Lower Cambrian near the top of the dark bluish-gray limestone (53 feet=16 m.) forming 3 of Mount Whyte formation, just above the tunnel, north shoulder of Mount Stephen, 3 miles (4.8 km.) east of Field, all in British Columbia, Canada.

#### PTYCHOPARIA SKAPTA, new species

Plate 12, figs. 9, 9a

Species known from an imperfect cranidium.

*Cranidium*.—Cranidium small, rather strongly contoured. Glabella relatively large, trapezoidal in outline, the anterior extremity truncate and approximately three-fourths as wide as the base; dorsal furrows linear, quite deeply incised; anterior furrow distinct but not so deep as the dorsal; glabellar furrows dissecting the sides of the glabella but entirely obsolete upon the crest; posterior pair more produced and more strongly oblique than the medial; anterior pair reduced to a couple of small pits just within the dorsal furrows; occipital groove narrow, very shallow upon the crest of the glabella, deep toward the dorsal furrows; occipital ring imperfectly preserved, narrow on the sides and widening towards the center. Fixed cheeks

<sup>1</sup> Canadian Alpine Journ., Vol. 1, 1908, pp. 240-242.

also imperfectly preserved but certainly wide and rather plump; postero-lateral lobe known only from the proximal portion; posterior groove in line with the occipital ring. Palpebral lobe not preserved. Palpebral ridge low and narrow, arching obliquely across the fixed cheeks and intercepting the dorsal furrows directly behind the anterior extremity of the glabella. Frontal limb flattened and in front of the glabella almost obliterated, expanded laterally, cut off from the frontal border by a wide and angular channel. Border thickened, elevated, rather narrow laterally, expanded medially. Other characters not preserved.

*Surface.*—Exterior surface finely granular.

*Dimensions.*—Length of cranidium, 4.5 mm.; length of glabella, 3.2 mm.; width of glabella in front, 1.8 mm.; width of glabella at base, 2.4 mm.

*Type locality.*—(62w) Above Gog Lake, Wonder Pass.

*Observations.*—*P. skapta* is, unfortunately, described from a unique type. *P. pia*, a much larger form, is probably the most closely allied of the known species. They resemble one another in the general contour, the outline of the glabella, the wide fixed cheeks, and the thickened frontal limb, posteriorly produced and angulated medially. *P. skapta* is, however, only about half as large as *P. pia*, the medial ridge of the glabella is a little more elevated, the dorsal and glabellar furrows are more deeply incised, the fixed cheeks more plump, the frontal limb much more reduced, and the frontal border heavier but not so wide.

*Formation and locality.*—Lower Cambrian: (62w) Mount Whyte formation; oolitic limestone, about 400 feet (123 m.) below summit of ridge above Gog Lake below Wonder Pass on Continental Divide, in British Columbia, 19 miles (30.4 km.) southwest of Banff, Alberta, Canada.

PTYCHOPARIA THIA, new species

Plate 12, fig. 6

Species known from imperfect cranidia.

*Cranidium.*—Glabella small relatively, broadly convex, rudely trapezoidal in outline, quite truncate in front, the sides roughly parallel; dorsal furrows shallow and not sharply defined; glabellar furrows narrow, occasionally distinct but never conspicuous, obsolete upon the crest of the glabella; posterior pair oblique, the medial pair diverging slightly from the horizontal, the anterior pair normal to the axis; occipital groove moderately broad and moderately deep, uniformly depressed throughout its extent; occipital ring rather

narrow, expanded medially, moderately elevated, not nodose. Fixed cheeks low and broad, and gently convex; postero-lateral lobe imperfectly preserved; posterior groove narrow and not very deep. Palpebral lobe short but quite prominent, feebly crescentic, placed quite far back in line with the lobe between the posterior and medial furrows. Palpebral ridge narrow and very obscure, arching obliquely across the fixed cheeks and intercepting the dorsal furrows directly behind the anterior extremity of the glabella. Frontal limb and border imperfectly differentiated, the two together of about the same width as the fixed cheeks and contoured very much like them. Frontal border a little more thickened and consequently a little more elevated than the limb, the medial portion posteriorly produced into an obtuse angle which closely approximates the anterior extremity of the glabella. Facial sutures imperfectly preserved, the anterior segment probably arcuate. Other characters not preserved.

*Surface*.—Exterior surface shagreened but not granulated.

*Dimensions*.—Length of cranium, 4.2 mm.; length of glabella, 2.9 mm.; width of glabella in front, 2.0 mm.; width of glabella at base, 1.5 mm.

*Type locality*.—(35h) Mount Bosworth.

*Observations*.—The diagnostic characters of the species are the rudely rectangular glabella, the wide, gently convex fixed cheeks, and the ill-differentiated border and limb which together with the cheeks form a frame about the glabella of approximately uniform width and convexity.

*Ptychoparia thia* is smaller than either *P. lux* or *adina*; the fixed cheeks are much wider than in *adina*; the glabella is broader relatively and less tapering anteriorly, and the frontal border is much more obscurely differentiated than in *lux*. The distribution is wider in *thia* than in either of the other species in question.

*Formation and locality*.—Lower Cambrian: Mount Whyte formation; (35h) about 375 feet (114 m.) below the Middle Cambrian, in shales, on Mount Bosworth, north of the Canadian Pacific Railway between Hector and Stephen, on the Continental Divide between British Columbia and Alberta; (35f, 58k) just above the tunnel, north shoulder of Mount Stephen, 3 miles (4.8 km.) east of Field, British Columbia; 35f is near the base of the Mount Whyte formation in stratum 6 and 58k about 295 feet (89.9 m.) above near the summit of the formation in stratum 1;<sup>1</sup> and (62w) oolitic limestone, about 400 feet (123 m.) below summit of ridge above

<sup>1</sup> Canadian Alpine Journ., Vol. 1, 1908, pp. 240-242.

Gog Lake below Wonder Pass on Continental Divide, in British Columbia, 19 miles (30.4 km.) southwest of Banff, Alberta, Canada.\*

**PTYCHOPARIA, species undetermined**

Fragments of the cranidia of what may be three species of *Ptychoparia* occur in the Mount Whyte formation, none of which have been identified with known species. As the genus is well represented by the described species I shall not now describe or illustrate the fragments.

**Genus CREPICEPHALUS Owen**

*Crepicephalus* OWEN, 1852. For synonymy and discussion of this genus see Smithsonian Misc. Coll., Vol. 64, 1916, pp. 199-204.

At the time I was studying the species referred to *Crepicephalus* the specimens of the species from the Mount Whyte formation and from the Mount Bosworth section were not to be found. The two species from the Mount Whyte formation are from the upper beds a short distance beneath the Middle Cambrian Ptarmigan formation. They are *C. cecinna* (pl. 11, figs. 1, 1a) and *C. celer* (pl. 11, fig. 2). The first species belongs to the *C. iowensis*<sup>1</sup> group of species, and *C. celer* to the *C. unca* form,<sup>2</sup> both of which are well represented in the Upper Cambrian. The two species from the Pioche formation of Nevada, *C. augusta* and *C. liliana*,<sup>3</sup> correspond in type, as far as we know them, to the Mount Whyte formation species, *C. cecinna* and *C. celer*, which occur at an horizon that is characterized by a Lower Cambrian fauna, although at the localities at which they were found neither of the genera *Olenellus* or *Mesonacis* was found in association with them. Very little attention was paid to searching for any particular grouping of species and the collections made except at two or three localities were very limited. The association of species that have been found with *Crepicephalus* and with *Olenellus* or *Mesonacis* is as follows. The localities are numbered and a similar number placed on each specimen.

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<sup>1</sup> Smithsonian Misc. Coll., Vol. 64, 1916, p. 201.

<sup>2</sup> Idem, pl. 35, figs. 1d, 1e.

<sup>3</sup> Idem, pl. 29, figs. 5, 6.

Names	58k Mount Stephen	61d Mount Shaffer	62w Gog Lake	63a Ptarmigan Pass
<i>Archæocyathus (A.) atreus</i> .....	..	..	×	..
<i>Micromitra (Paterina) labradorica</i> ..	..	×	×	..
<i>Micromitra (Iphidella) pannula</i> .....	..	×	..	..
<i>Kutorgina cf. cingulata</i> .....	..	..	×	..
<i>Acrotreta sagittalis taconica</i> .....	×	×	×	..
<i>Nisusia (Jamesella) lowi</i> .....	..	×	×	×
<i>Wimanella catulus</i> .....	..	..	..	×
<i>Helcionella elongata</i> .....	×	..	×	..
<i>Pelagiella sp. undt.</i> .....	..	×	..	..
<i>Scenella varians</i> .....	×	×	×	..
<i>Parmophorella sp.</i> .....	×	..	..	..
<i>Hyalithes billingsi</i> .....	×	..	×	×
<i>Hyalithellus sp. undt.</i> .....	..	..	×	..
<i>Shafferia cisina</i> .....	..	×	..	..
<i>Agraulos unca</i> .....	..	×	..	..
<i>Olenopsis agnesensis</i> .....	×	..	..	..
<i>Olenopsis cleora</i> .....	..	..	×	..
<i>Zacanthoides sp.</i> .....	..	×	..	..
<i>Ptychoparia cercops</i> .....	..	..	..	×
<i>Ptychoparia clusia</i> .....	×	..	..	..
<i>Ptychoparia cf. gogensis</i> .....	..	..	×	..
<i>Ptychoparia lux</i> .....	..	×	..	..
<i>Ptychoparia skapta</i> .....	..	..	×	..
<i>Ptychoparia thia</i> .....	×	..	×	..
<i>Crepicephalus cecinna</i> .....	..	..	×	×
<i>Crepicephalus celer</i> .....	×	..	..	..
<i>Dorypyge damia</i> .....	..	..	×	..
<i>Corynexochus senectus</i> .....	..	×	..	..
<i>Mesonacis gilberti</i> .....	..	×	..	..
<i>Bathyriscus (Poliella) primus</i> ....	×	..	..	..

**CREPICEPHALUS CECINNA, new species**

Plate II, figs. I, 1a-b

Species known from a cranidium and a few associated pygidia.

*Cranidium*.—Cranidium short and broad. Glabella relatively large, subtrapezoidal in outline, a little less than five-sixths as long as the cranidium, and about four-fifths as wide in front as it is at the base; dorsal furrows deeply impressed, terminating anteriorly in small pits; anterior furrow not quite so deep as the dorsal, very feebly arcuate; glabellar furrows moderately broad and quite deep, not persistent, however, across the low medial ridge; posterior pair a little more strongly oblique than the medial; anterior pair obscure,

much shorter than the furrows behind them and nearly at right angles to the axis of the shield; occipital furrow sinuous, deep distally, bent forward upon the crest of the glabella and only partially dissecting it; occipital ring very narrow laterally, expanded medially, bearing near the posterior margin a small sharp node. Fixed cheeks low and broad, the distance from the palpebral lobe to the dorsal furrow decidedly more than half the width of the medial portion of the glabella; postero-lateral lobe not preserved but necessarily narrow; posterior furrow narrow, deep. Palpebral lobe not preserved, apparently small, not very prominent and placed far back opposite the posterior lobe of the glabella. Palpebral ridge narrow, cordate, quite sharply elevated, curving obliquely across the fixed cheeks, and intercepting the dorsal furrows a little behind the anterior extremity, thus enclosing a rudely elliptical area interrupted by the glabella. Frontal limb narrow medially, of approximately the same width as the thickened cordate frontal border, from which it is separated by a narrow but rather deeply incised groove. Other characters of the cephalon not preserved.

*Pygidium*.—Pygidium short and broad, the lateral margins diverging slightly posteriorly, the anterior and posterior margins exclusive of the spines roughly parallel. Axial lobe rather low and flattened upon its summit, obtusely truncate posteriorly; axial annulations quite distinct anteriorly, somewhat flexuous, indicating 5 or 6 component segments and a terminal section; pleural lobes exclusive of the spines, moderately convex, deeply furrowed, the grooves increasingly shallow and more closely spaced posteriorly; interspaces elevated parallel to the anterior lateral margin, the anterior ridges obtusely angulated and nodose at the angles, gradually dying out along an arc of about  $180^{\circ}$ ; postero-lateral extremities flattened and produced into slender, slightly diverging spines of approximately the same length as the axial lobe of the pygidium.

*Surface*.—Exterior surface very finely granulated; a few much coarser granules scattered over the frontal limb and border.

*Dimensions*.—Length of cranidium, 4.3 mm.; length of glabella, 3.5 mm.; width of glabella in front, 2.0 mm.; width of glabella at base, 2.5 mm.; length of pygidium exclusive of the terminal spines, 5.0 mm.; length of pygidium including the terminal spines, 10.0 mm.; width of medial portion of pygidium, 8.5 mm.

*Type locality*.—(63a) Ptarmigan Peak.

*Observations*.—Two distinct systems of surface sculpture are developed in this species, a fine, close granulation over the entire surface and a coarse, sparse granulation upon the frontal limb and

border and probably upon the pygidium. *P. carina*, the only other form which has a similar surface, is much larger and the glabella is much more strongly rounded anteriorly than in *C. cecinna*.

Both the cranidium and associated pygidium of this species are closely related to *Crepicephalus upis* of the Upper Cambrian Gallatin limestone of Montana.<sup>1</sup> They are also closely related in form to *C. liliana*,<sup>2</sup> from strata referred to the upper zone of the Lower Cambrian of Nevada. *C. cecinna* is not closely related to *C. chares* of the Ptarmigan formation.<sup>3</sup>

*Formation and locality.*—Lower Cambrian: Mount Whyte formation; (63a) oolitic limestone about 130 feet (40 m.) above arenaceous shaly beds; east base of Ptarmigan Peak, 5.5 miles (8.8 km.) in an air line northeast of Lake Louise station on the Canadian Pacific Railway, Alberta; also (62w) oolitic limestone, about 400 feet (123 m.) below summit of ridge above Gog Lake below Wonder Pass on Continental Divide, in British Columbia, 19 miles (30.4 km.) southwest of Banff, Alberta, Canada.

#### CREPICEPHALUS CELER, new species

Plate II, fig. 2

Species known from the pygidium.

*Pygidium.*—Pygidium rudely quadrate in outline exclusive of the posterior constriction, the lateral margins approximately parallel to the axis; anterior margin broken by the forward curve of the axial lobe; posterior margin very broadly and deeply insinuated. Axial lobe large and coarse, broadly conic in outline, acutely tapering posteriorly; axial annulations probably very distinct in perfectly preserved individuals, including apparently 6 component segments and a terminal section. Pleural lobes flexuous, irregular in outline, the anterior lateral margin an obtuse right angle; pleural furrows following the same general direction as the outer margin but less angulated, disappearing abruptly along an imaginary arc of about 180°; extremities of pleural lobes produced into cuneate appendages, acutely tapering.

*Surface.*—Exterior surface unknown.

*Dimensions.*—Length of pygidium including the lateral spines, 19.5 mm.; length of pygidium to the medial posterior margin, 12.5 mm.; greatest width of pygidium, 15.0 mm.

<sup>1</sup> Smithsonian Misc. Coll., Vol. 64, 1916, pl. 33, figs. 4, 4a-d.

<sup>2</sup> Idem, pl. 29, figs. 5, 5a-c.

<sup>3</sup> Idem., Vol. 67, 1917, pl. 6, figs. 5, 5a-c.

*Type locality*.—(58k) Mount Stephen.

*Observations*.—*C. celer* is represented by a single specimen of a large pygidium of the *C. chares*<sup>1</sup> type from the Ptarmigan formation. It differs from the pygidium of the latter species in having a much larger axial lobe; in this character it approaches *C. unca* of the Upper Cambrian of Minnesota.<sup>2</sup>

A small cranium associated with the pygidium may belong to this species, but it is too imperfect to identify even as belonging to the genus.

*Formation and locality*.—Lower Cambrian: Mount Whyte formation; (58k) about 5 feet (1.5 m.) below the top of the Lower Cambrian in thin-bedded bluish-black and gray limestone, just above the tunnel, north shoulder of Mount Stephen, 3 miles (4.8 km.) east of Field, British Columbia, Canada.

#### DORYPYGE DAMIA, new species

Plate 11, figs. 7, 7a

Species known from imperfect crania and pygidia.

*Cephalon*.—Glabella broadly and rather strongly convex, subcylindrical in outline and slightly contracted anteriorly; dorsal furrows narrow but quite deeply impressed, terminating anteriorly in a couple of small pits; anterior furrow very narrow and separating a wire-like border from the glabella; anterior extremity rounded; glabellar furrows reduced to a posterior and medial pair of short shallow linear depressions just within the dorsal furrows; occipital furrow almost obsolete upon the summit of the glabella, narrow but quite deeply incised towards the dorsal furrows; occipital ring moderately wide, imperfectly preserved. Fixed cheeks also imperfectly preserved, rather narrow, and gently convex; groove of postero-lateral lobe quite broad but not very deep, in line with the occipital ring. Palpebral lobe not preserved. Palpebral ridge feebly indicated by an obtuse angulation of the cheek a little behind and parallel to the anterior extremity. Frontal limb practically obsolete in front of the glabella. Other characters unknown.

*Pygidium*.—Associated pygidium rather large, semielliptical in outline. Axial lobe quite strongly convex, of approximately the same width as the pleural lobe; tapering gradually toward the obtusely rounded posterior extremity which falls just within the peripheral rim; axial annulations coarse and distinct even toward

<sup>1</sup> Smithsonian Misc. Coll., Vol. 67, 1917, pl. 6, figs. 5b, 5c.

<sup>2</sup> Idem. Vol. 64, 1916, pl. 35, figs. 1d, 1e.

the posterior extremity, indicating 5 component segments and a terminal section. Pleural lobes flattened; traces of the anchylosed segments still retained in the broad and shallow pleural grooves, which become increasingly shallow and approach more and more closely to the axis of the shield toward the posterior extremity. Peripheral rim narrow, flattened and with 5 very sharp short spines on each side which are more strongly inclined posteriorly; they correspond in number and position to the component anchylosed segments.

*Surface*.—Exterior surface finely granulated.

*Dimensions*.—Length of type cranidium,  $11.0 \pm$  mm.; length of glabella,  $10.0 \pm$  mm.; width of glabella at base,  $7.0 \pm$  mm.; length of pygidium exclusive of serrations,  $11.0 \pm$  mm.; width of pygidium anteriorly, exclusive of serrations,  $18.0 \pm$  mm.

*Type locality*.—(62w) Wonder Pass.

*Observations*.—The cranidium of this species at once recalls that of *Dorypyge richthofeni* Dames, from China.<sup>1</sup> It differs in its finer squamose granulation. The associated pygidia are also quite unlike those associated with the Chinese species.

*Formation and locality*.—Lower Cambrian: (62w) Mount Whyte formation; No. 1 of section; oolitic limestone; about 400 feet (123 m.) below summit of ridge above Gog Lake below Wonder Pass on Continental Divide, in British Columbia, 19 miles (30.4 km.) southwest of Banff, Alberta, Canada.

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<sup>1</sup> Research in China, Carnegie Inst. of Washington, Pub. No. 54, Vol. 3, 1913, pl. 8, figs. 1, 1b.

## DESCRIPTION OF PLATE 8

- |   | PAGE   |
|---|--------|
| <i>Gogia prolifica</i> Walcott.....   | 68     |
| <p>FIG. 1. (Natural size.) Calyx with 5 arms and outline of stem. U. S. National Museum, Catalogue No. 64350.</p>   |        |
| <p>1a. (× 3.) Stem and calyx of the specimen illustrated by fig. 1b. The plates have been removed by solution, so that the cast of the inner surface of the plate of the calyx and of the outer surface of the plates of the stem is shown.</p> |        |
| <p>1b. (Natural size.) Calyx, stem and arms of specimen shown by fig. 1a. A small calyx is seen on the upper end of the piece of rock. Note the long arms. U. S. National Museum, Catalogue No. 64351.</p>                                      |        |
| <p>The specimens represented by figs. 1, 1a-b, are from locality <b>62x</b>, Lower Cambrian: Mount Whyte formation; above Gog Lake, Wonder Pass, British Columbia.</p>  |        |
| <br><i>Archæocyathus</i> ( <i>Archæocyathellus</i> ) <i>atreus</i> Walcott.....   | <br>67 |
| <p>FIG. 2. (× 4.) Portion of a slender corolla with matrix of its extension.</p>  |        |
| <p>2'. Cross section of fig. 2, showing thickness of wall.</p>  |        |
| <p>2a. (× 4.) An irregular corolla with strong undulations of growth. (This is on the same block with fig. 2.) U. S. National Museum, Catalogue No. 64352.</p>  |        |
| <p>The specimens represented by figs. 2, 2a, are from locality <b>62w</b>, Lower Cambrian: Mount Whyte formation; above Gog Lake, Wonder Pass, British Columbia.</p>  |        |



2a

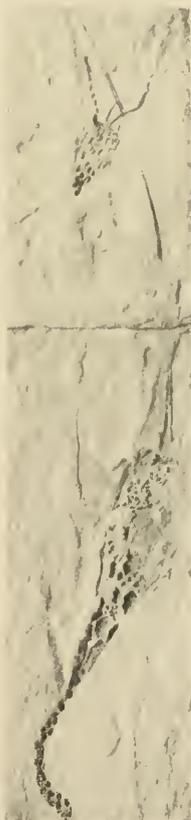
2



2'



1a



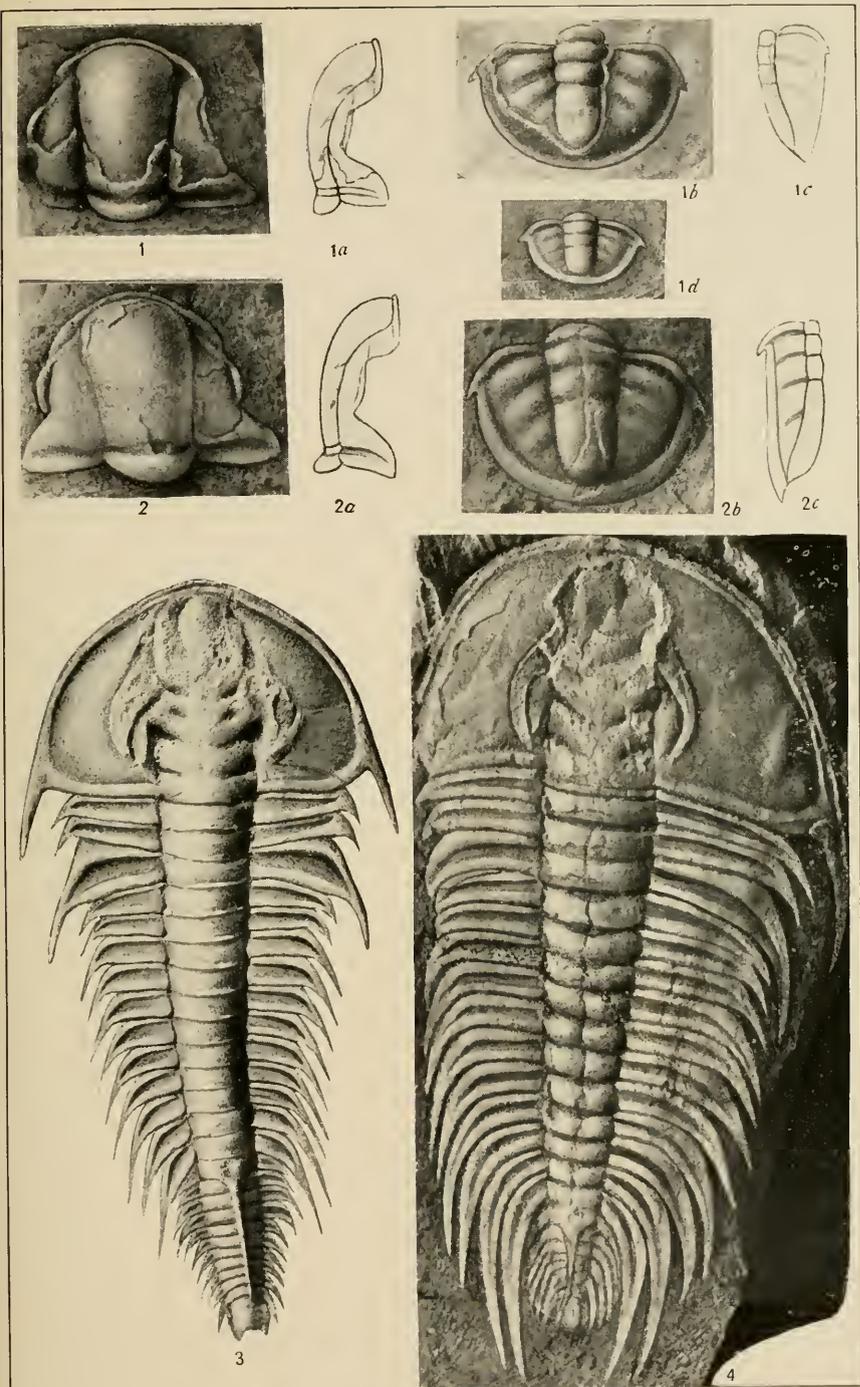
1b





## DESCRIPTION OF PLATE 9

- |  | PAGE |
|--|------|
| <i>Corynexochus senectus</i> (Billings).....   | 66   |
| <p>FIGS. 1, 1a. (× 3.) Dorsal view and side outline of cranium with most of test exfoliated. U. S. National Museum, Catalogue No. 62726.</p> <p>1b, 1c. (× 4.) Dorsal and side view of a pygidium. U. S. National Museum, Catalogue No. 62731.</p> <p>1d. (× 4.) Small pygidium. U. S. National Museum, Catalogue No. 62733.</p> <p>From limestone at locality 411, Lower Cambrian: Bonne Bay, Newfoundland.</p> <p>The specimens represented by figs. 1, 1a-d have been figured by Walcott, Smithsonian Misc. Coll., Vol. 64, No. 5, 1916, pl. 56, figs. 1, 1', 1e, 1e', and 1f, respectively.</p> <p>2, 2a. (× 3.) Dorsal and side views of a partially exfoliated cranium, with slight indication of lateral glabellar furrows. U. S. National Museum, Catalogue No. 62722.</p> <p>2b, 2c. (× 3.) An associated pygidium that has been slightly elongated. U. S. National Museum, Catalogue No. 62723.</p> <p>From locality 61d, Lower Cambrian: Mount Whyte formation; southwest slope of Mount Shaffer, British Columbia.</p> <p>The specimens represented by figs. 2, 2a-c, have been figured by Walcott, Smithsonian Misc. Coll., Vol. 64, No. 5, 1916, pl. 55, figs. 7, 7', 7a, and 7a', respectively.</p> |      |
| <i>Mesonacis vermontana</i> (Hall) .....   | 66   |
| <p>FIG. 3. (Natural size.) An entire dorsal shield from the type locality (25) at Georgia, Vermont, showing 14 thoracic segments of the <i>Olenellus</i> type, the spine-bearing segment, and ten segments of the <i>Mesonacis</i> type. U. S. National Museum, Catalogue No. 15399a.</p> <p>From locality 25, Lower Cambrian: Siliceous or finely arenaceous shale just above Parker's quarry, Georgia township, Franklin County, Vermont.</p> <p>The specimen represented by fig. 3 has been figured by Walcott, Smithsonian Misc. Coll., Vol. 53, No. 6, 1910, pl. 26, fig. 1; also idem, Vol. 64, No. 5, 1916, pl. 45, fig. 2.</p>   |      |
| <i>Mesonacis gilberti</i> (Meek).....  | 66   |
| <p>FIG. 4. (About ½ natural size.) The illustration is taken from a plaster cast of the specimen now in the Geological Museum of Princeton University, Princeton, New Jersey, which was from locality 35n, Lower Cambrian: Mount Whyte formation; eastern slope of Mount Odaray, above McArthur Pass, British Columbia. Plastotype. U. S. National Museum, Catalogue No. 62619.</p> <p>The specimen represented by fig. 4 has been figured by Walcott, Smithsonian Misc. Coll., Vol. 64, No. 5, 1916, pl. 45, fig. 3.</p>  |      |



LOWER CAMBRIAN TRILOBITES





## DESCRIPTION OF PLATE 10

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|---|------|
| <i>Corynexochus (Bonnia) parvulus</i> (Billings).....   | 65   |
| <p>FIGS. 1, 1a. (× 3.) Dorsal and side views of a finely preserved cranidium. U. S. National Museum, Catalogue No. 62744.</p> <p>1b, 1c. (× 3.) Dorsal and side views of a pygidium. U. S. National Museum, Catalogue No. 62745.</p> <p>From the limestone of locality <b>41k</b>, Lower Cambrian: Forteau Bay, Labrador.</p> <p>The specimens represented by figs. 1, 1a-c, have been figured by Walcott, Smithsonian Misc. Coll., Vol. 64, No. 5, 1916, pl. 57, figs. 1b, 1b', 1c, and 1c', respectively.</p>   |      |
| <i>Corynexochus (Bonnia) fieldensis</i> (Walcott).....  | 65   |
| <p>FIGS. 2, 2a. (× 3.) Dorsal and side views of the type cranidium. U. S. National Museum, Catalogue No. 62751.</p> <p>2b, 2c. (× 3.) Dorsal and side views of a pygidium associated with the cranidium represented by fig. 2. U. S. National Museum, Catalogue No. 62752.</p> <p>From the limestone locality <b>35l</b>, Lower Cambrian: Ptarmigan Pass, Alberta.</p> <p>The specimens represented by figs. 2, 2a-c have been figured by Walcott, Smithsonian Misc. Coll., Vol. 64, No. 5, 1916, pl. 57, figs. 4, 4', 4a, and 4a', respectively.</p>   |      |
| <i>Micromitra (Paterina) charon</i> Walcott.....  | 69   |
| <p>FIG. 3. (× 3.) Ventral valve flattened by compression in the siliceous shale. U. S. National Museum, Catalogue No. 64353.</p> <p>3a. (× 4.) Flattened dorsal valves, one of which shows the reticulated surface. U. S. National Museum, Catalogue No. 64354.</p> <p>3b. (× 6.) Two small ventral valves with very little distortion. U. S. National Museum, Catalogue No. 64355.</p> <p>The specimens represented by figs. 3, 3a-b are from siliceous shales of the Mount Whyte formation (<b>61c</b>) on Mount Odaray, British Columbia.</p>  |      |
| <i>Acrothele clitus</i> Walcott.....  | 70   |
| <p>FIG. 4. (× 6.) An exfoliated and crushed ventral valve. U. S. National Museum, Catalogue No. 64356.</p> <p>4a. (× 6.) A crushed ventral valve with the shell preserved. U. S. National Museum, Catalogue No. 64357.</p> <p>4b. (× 6.) Cast in the shale of the interior of a dorsal valve. U. S. National Museum, Catalogue No. 64358.</p> <p>4c. (× 6.) Interior of a dorsal valve. (On same piece as 4b.) U. S. National Museum, Catalogue No. 64359.</p> <p>The specimens represented by figs. 4, 4a-c are from the fine siliceous Lake Agnes shale (<b>35e</b>) of the Mount Whyte formation, above the head of Lake Agnes, Alberta.</p> |      |



1



1a



1b



1c



2



2a



2b



2c



3



3a



3b



4



4a



4b



4c



5a



5



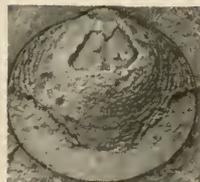
5b



5c



6



6a



	PAGE
<i>Wimanelia catulus</i> Walcott.....	70
FIGS. 5, 5a. (× 1.5.) Top and side view of a ventral valve from which the outer shell is exfoliated. U. S. National Museum, Catalogue No. 64360.	
5b. (× 1.5.) Cast of the interior of a ventral valve showing traces of the great vascular sinuses. U. S. National Museum, Catalogue No. 64361.	
5c. (× 1.5.) Cast of the exterior of a dorsal valve. U. S. National Museum, Catalogue No. 64362.	

The specimens represented by figs. 5, 5a-c are from oolitic limestone near the summit of the Mount Whyte formation (63a), east base of Ptarmigan Peak, Alberta.

<i>Obolus damo</i> Walcott.....	69
FIG. 6. (× 4.) Exfoliated ventral valve. U. S. National Museum, Catalogue No. 64363.	
6a. (× 6.) Cast of interior of a ventral valve. U. S. National Museum, Catalogue No. 64364.	

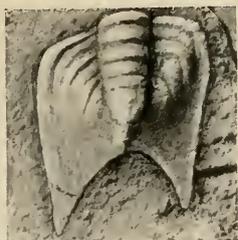
The specimens represented by figs. 6, 6a are from locality 63g, Lower Cambrian: Mount Whyte formation; greenish arenaceous shale, southwest slope of Mount Temple, Alberta.

## DESCRIPTION OF PLATE II

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<i>Crepicephalus cecinna</i> Walcott.....	99
FIG. 1. (X 4.) A broken cranidium, the type of the species showing the tuberculated surface. U. S. National Museum, Catalogue No. 64365.	
1a. (X 4.) Pygidium associated on the same piece of limestone with the cranidium represented by fig. 1. U. S. National Museum, Catalogue No. 64366.	
1b. (X 4.) Side outline of the pygidium represented by fig. 1a.	
The specimens represented by figs. 1, 1a-b are from locality 63a, Lower Cambrian: Mount Whyte formation; Ptarmigan Peak, Alberta.	
<i>Crepicephalus celer</i> Walcott.....	101
FIG. 2. (X 1.5.) View of the type specimen of the pygidium, which is slightly distorted. U. S. National Museum, Catalogue No. 64367.	
From locality 58k, Lower Cambrian: Mount Whyte formation; Mount Stephen, British Columbia.	
<i>Ptychoparia clusia</i> Walcott.....	85
FIGS. 3, 3a. (X 3.) Top view and side outline of the type cranidium of the species. U. S. National Museum, Catalogue No. 64368.	
From locality 58k, Lower Cambrian: Mount Whyte formation; Mount Stephen, British Columbia.	
<i>Ptychoparia cuncas</i> Walcott.....	87
FIGS. 4, 4a. (X 3.) Top and side view of the type cranidium of the species. U. S. National Museum, Catalogue No. 64369.	
From locality 35f, Lower Cambrian: Mount Whyte formation; Mount Stephen, British Columbia.	
<i>Ptychoparia cossus</i> Walcott.....	86
FIGS. 5, 5a. (X 3.) Top view and side outline of the type specimen of the cranidium. U. S. National Museum, Catalogue No. 64370.	
From locality 61a, Lower Cambrian: Mount Whyte formation; gray oolitic siliceous limestone, Yoho Canyon, British Columbia.	
<i>Olenopsis crito</i> Walcott.....	75
FIG. 6. (Natural size.) The type specimen of a large cranidium, which has been partially restored on the right side. U. S. National Museum, Catalogue No. 64371.	
6a. (Natural size.) Interior of free cheek associated with the cranidium represented by fig. 6. U. S. National Museum, Catalogue No. 64372.	



1



2



3



1a



1b



3a



4



5



5a



4a



6



7



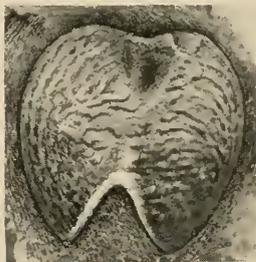
6a



6b



7a



8



8a



*Olenopsis crito* Walcott—Continued.

PAGE

6b. (Natural size.) A small broken cranidium associated in the same layer of shaly calcareo-arenaceous sandstone with the specimen represented by fig. 6. U. S. National Museum, Catalogue No. 64373.

The specimens represented by figs. 6, 6a-b are from locality **60e**, Lower Cambrian: Mount Whyte formation; Ptarmigan Lake Pass, Alberta.

*Dorypge damia* Walcott..... 102

FIG. 7. (× 1.5.) Fragment of a cranidium and pygidium on a small piece of limestone. U. S. National Museum, Catalogue No. 64374.

7a. (× 1.5.) Pygidium associated with the cranidium represented on fig. 7. U. S. National Museum, Catalogue No. 64375.

The specimens represented by figs. 7, 7a are from locality **62w**, Lower Cambrian: Mount Whyte formation; oolitic limestone, ridge above Gog Lake, British Columbia.

*Shafferia cisina* Walcott..... 71

FIG. 8. (× 6.) View looking directly down on the type specimen of the carapace from above. U. S. National Museum, Catalogue No. 64376.

8a. (× 6.) Side view of the carapace illustrated by fig. 8.

From locality **61d**, Lower Cambrian: Mount Whyte formation; oolitic limestone, southwest slope of Mount Shaffer, British Columbia.

## DESCRIPTION OF PLATE 12

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|--|--------|
| <i>Ptychoparia? cercops</i> Walcott.....   | 81     |
| FIG. 1. (Natural size.) A broken cranidium from which the test has been exfoliated. U. S. National Museum, Catalogue No. 64377.  |        |
| 1a. (× 4.) A small cranidium associated with the specimen represented by fig. 1. This may be taken as the type cranidium of the species. U. S. National Museum, Catalogue No. 64378. |        |
| 1b. (× 3.) Free cheek, broken from the same piece of limestone as the specimen represented by fig. 1a. U. S. National Museum, Catalogue No. 64379.                                   |        |
| 1c. (× 4.) Fragment of a thoracic segment associated with cranidia of this species. U. S. National Museum, Catalogue No. 64380.  |        |
| 1d. (× 4.) Pygidium broken from the same piece of rock containing the cranidium illustrated by fig. 1a. U. S. National Museum, Catalogue No. 64381.                                  |        |
| The specimens represented by figs. 1, 1a-d are from locality 63c, Lower Cambrian: Mount Whyte formation; Ptarmigan Peak.   |        |
| <br><i>Ptychoparia? cleadas</i> Walcott.....   | <br>83 |
| FIG. 2. (× 6.) Type cranidium of the species. U. S. National Museum, Catalogue No. 64382.  |        |
| From locality 57s, Lower Cambrian: Mount Whyte formation; near the base of the gray oolitic limestone, on Mount Bosworth, British Columbia.  |        |
| <br><i>Ptychoparia adina</i> Walcott.....  | <br>78 |
| FIG. 3. (× 6.) Type cranidium of the species. U. S. National Museum, Catalogue No. 64383.  |        |
| 3a. (× 6.) A free cheek occurring on the same piece of limestone with the cranidium represented by fig. 3. U. S. National Museum, Catalogue No. 64384.                               |        |
| 3b. (× 3.) A small pygidium broken from the piece of limestone containing the cranidium represented by fig. 3. U. S. National Museum, Catalogue No. 64385.                           |        |
| The specimens represented by figs. 3, 3a-b are from locality 57q, Lower Cambrian: Mount Whyte formation; drift block on the south slope of Mount Bosworth.                           |        |
| <br><i>Ptychoparia gogensis</i> Walcott.....   | <br>88 |
| FIGS. 4, 4a. (× 2.) Top and side view of the type cranidium of the species. U. S. National Museum, Catalogue No. 64386.  |        |
| From locality 62w, Lower Cambrian: Mount Whyte formation; above Gog Lake, Wonder Pass.   |        |



1



1a



1b



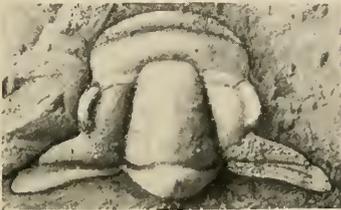
1c



1d



2



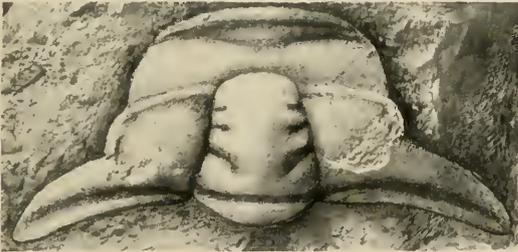
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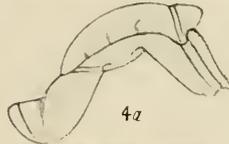
3a



3b



4



4a



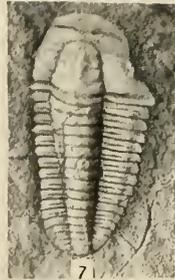
5



8



6



7



10



9



9a



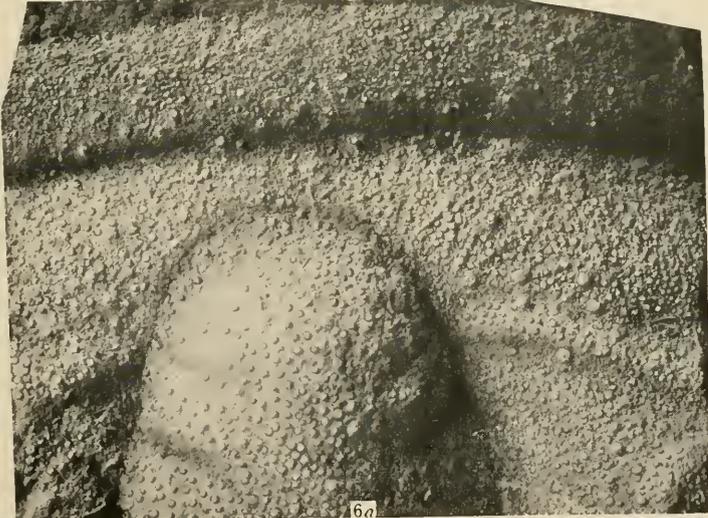
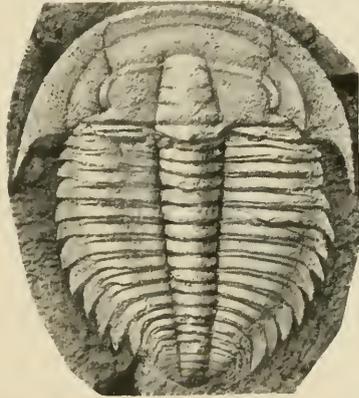
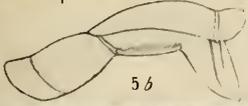
7a



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LOWER CAMBRIAN TRILOBITES