

SMITHSONIAN MISCELLANEOUS COLLECTIONS

VOLUME 57, NUMBER 5

# CAMBRIAN GEOLOGY AND PALEONTOLOGY

II

No. 5.—MIDDLE CAMBRIAN ANNELIDS

WITH SIX PLATES

BY

CHARLES D. WALCOTT



(PUBLICATION 2014)

CITY OF WASHINGTON  
PUBLISHED BY THE SMITHSONIAN INSTITUTION  
SEPTEMBER 4, 1911

The Lord Baltimore Press  
BALTIMORE, MD., U. S. A.

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## II

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#### CONTENTS

	PAGE
Introduction .....	110
Cambrian annelids .....	111
Classification .....	111
Relations to living annelids .....	111
Descriptions	
Class Chætognatha .....	112
Family Amiskwidæ, new family.....	112
Genus <i>Amiskwia</i> , new genus.....	112
<i>Amiskwia sagittiformis</i> , new species.....	112
Class Chætopoda .....	113
Sub-Class Polychæta .....	113
Order Miskoa, new order.....	113
Family Miskoïdæ new family.....	113
Genus <i>Miskoia</i> , new genus.....	114
<i>Miskoia preciosa</i> , new species.....	114
Family Aysheaidæ, new family.....	116
Genus <i>Aysheia</i> , new genus.....	116
<i>Aysheia pedunculata</i> , new species.....	117
Family Canadidæ, new family.....	117
Genus <i>Canadia</i> , new genus.....	118
<i>Canadia spinosa</i> , new species.....	118
<i>Canadia setigera</i> , new species.....	119
<i>Canadia sparsa</i> , new species.....	119
<i>Canadia dubia</i> , new species.....	119
<i>Canadia irregularis</i> , new species.....	120
Genus <i>Selkirkia</i> , new genus.....	120
<i>Selkirkia major</i> (Walcott).....	120
<i>Selkirkia fragilis</i> , new species.....	122
<i>Selkirkia gracilis</i> , new species.....	122
Family <i>Wiwaxidæ</i> , new family.....	123
Genus <i>Wiwaxia</i> , new genus.....	123
<i>Wiwaxia corrugata</i> (Matthew) .....	123
Genus <i>Pollingeria</i> , new genus.....	124
<i>Pollingeria grandis</i> , new species.....	125
Genus <i>Worthenella</i> , new genus.....	125
<i>Worthenella cambria</i> , new species.....	126

Class Gephyrea—Quatrefages.....	127
Family Ottoïdæ, new family.....	128
Genus <i>Ottoia</i> , new genus.....	128
<i>Ottoia prolifica</i> , new species.....	128
<i>Ottoia minor</i> , new species.....	129
<i>Ottoia tenuis</i> , new species.....	130
Genus <i>Banffia</i> , new genus.....	130
<i>Banffia constricta</i> , new species.....	130
Family Pikaidæ, new family.....	131
Genus <i>Pikaia</i> , new genus.....	131
<i>Pikaia gracilens</i> , new species.....	132
Genus <i>Oesia</i> , new genus.....	132
<i>Oesia disjuncta</i> , new species.....	133

## ILLUSTRATIONS

	PAGE
PLATE 18. <i>Miskoia preciosa</i> .....	134
19. Genera <i>Ottoia</i> , <i>Selkirkia</i> .....	136
20. Genera <i>Pikaia</i> , <i>Oesia</i> .....	138
21. Genera <i>Wiwaxia</i> , <i>Banffia</i> .....	140
22. Genera <i>Worthenella</i> , <i>Amiskwia</i> , <i>Ottoia</i> .....	142
23. Genera <i>Canada</i> , <i>Aysheia</i> .....	144

## INTRODUCTION

This is the third paper on Middle Cambrian fossils from the Burgess shale member of the Stephen formation of British Columbia. The first was on the Merostomata<sup>1</sup> and the second on the Holothurians and Medusæ.<sup>2</sup> We now have for consideration the annelids. As a rule the annelids have been known only by trails and borings in the muds and sands deposited in the various periods between the Pre-Cambrian Algonkian and the present, and only under very exceptional conditions have any traces of the actual animal been preserved. The most noted discoveries are those in the Upper Jurassic Solenhofen lithographic shales of Bavaria and the Eocene shales of Monte Bolca. Another discovery that has long escaped the attention of authors is that made by Dr. E. O. Ulrich and described by him in 1879.<sup>3</sup> These fossils appear to be true segmented Polychætous annelids from the Ordovician shale at Cincinnati, Ohio.

<sup>1</sup> Smithsonian Misc. Coll., Vol. 57, No. 2, 1911.

<sup>2</sup> Idem, No. 3.

<sup>3</sup> Journ. Cincinnati Soc. Nat. Hist., Vol. 1, 1879, pp. 87-91, pl. 4, figs. 1-4.

## CAMBRIAN ANNELIDS.

I have often searched the fine shales of the pre-Cambrian and Cambrian strata for remains of annelids but it was not until the summer of 1910 that anything more than trails and borings were found.

The annelids of the Burgess shale, like the holothurians and Medusæ, are pressed flat so that the animal is represented by only a thin film. Fortunately this is darker than the shale and usually shiny, and the contents of the animal are often preserved as a glistening silvery surface, even to the fine details of structure. How clearly the specimens exhibit both external and internal characters is shown by the plate figures which are reproduced from photographs made by reflected light. As it was impossible to bring out all the characters through light falling from one direction, the photographs were touched up by pencil, but not to such an extent as to introduce interpretation of structure not shown by the fossil.

*Classification.*—I have followed very largely the classification of Parker and Haswell's Text-Book of Zoology, Vol. 1, London, 1910.

The Class Chætognatha is represented by one genus and species, *Amiskwia sagittiformis*. The Class Chætopoda by six genera of the sub-class Polychæta as follows: *Miskoia*, *Aysheaia*, *Canadia*, *Worthenella*, *Pollingeria*, *Wiwaxia*, and *Scelkirkia*; and the Class Gephyrea by four genera: *Ottoia*, *Banffia*, *Pikaia*, and *Oesia*.

The list of families, genera, and species may be found in the table of contents.

*Relations to living annelids.*—The discovery of this remarkable group of annelids in the Burgess shale<sup>1</sup> member of the Stephen formation opens up a new point of view on the development of the Annulata. The fact that from one very limited locality there have been collected eleven genera belonging to widely separated families points clearly to the conclusion that the fundamental characters of all the classes had been developed prior to Middle Cambrian time. No examples of the Class Hirudinea have been recognized, but the segmentation of the Chætopoda is present in *Ottoia* and *Banffia*, annelids which otherwise are true Gephyreans. To a certain extent these two genera serve to link the Chætopoda and Hirudinea.

I should not be at all surprised to find representatives of the Archi-Annelida in the Burgess shale. Thus far the annelids collected were incidental to other fossils rather than a direct object of search.

<sup>1</sup> Smithsonian Misc. Coll., Vol. 57, No. 3, 1911, p. 51.

As in the case of the holothurians the annelids go to prove that the Cambrian fauna was highly developed and differentiated in pre-Cambrian Lipalian time.<sup>1</sup>

## ANNULATA

### Class CHÆTOGNATHA

#### AMISKWIDÆ, new family

Chætognatha allied by external form to *Sagitta*. Body divided into a head, trunk, and tail. One pair of lateral fins. An interior septum occurs between the head and body, but none is shown between the body and tail.

One genus, *Amiskwia*.

#### AMISKWIA, new genus

As there is but one species the generic and specific descriptions will be combined under the species.

*Genotype*.—*Amiskwia sagittiformis*, new species.

*Stratigraphic range*.—The stratigraphic range is limited to a band of dark siliceous shale about 4 feet in thickness forming a part of the Burgess shale member of the Stephen formation.

*Geographic distribution*.—On the slope of the ridge between Wapta Peak and Mount Field, north of Burgess Pass, and about 3800 feet above Field on the line of the Canadian Pacific Railway, British Columbia, Canada.

*Observations*.—*Amiskwia* resembles *Sagitta* superficially, but differs from the latter genus in the form of the head, the presence of strong tentacles, the absence of a hood about the head, the strong single pair of lateral fins, and the absence of a posterior septum.

Generic name derived from Amiskwi, name of a river west of Mount Burgess, British Columbia, Canada.

#### AMISKWIA SAGITTIFORMIS, new species

Plate 22, figs. 3 and 4

Body cylindrical and divided into a broadly elongate oval head, a cylindrical body, and an expanded tail. The head, expanding from the neck, contracts to a bluntly pointed anterior end, from the rounded angles of which project a pair of strong tentacles. The lateral fins of the body are a little more than one-third the length of

<sup>1</sup> Smithsonian Misc. Coll., Vol. 57, No. 1, 1910, p. 14.

the body and quite prominent. The tail is expanded and slightly transverse at the posterior margin.

The enteric canal and traces of other internal organs show quite clearly. In the head (fig. 3) a triangular-shaped area is outlined in front, and back of it a quadrate space. Posterior to the latter are two elongate oval spaces; from the outer side of the left of these three short hooks curve inward; these were undoubtedly beside the mouth. The enteric canal begins between the bases of the two oval spaces and terminates a little beyond the center of the tail. The anus doubtless existed at this point. A transverse, somewhat irregular line at the base of the oval spaces, indicates a thin septum separating the head and body cavities.

*Dimensions.*—The largest specimen has a length of 20 mm. Other proportions are shown by figures 3 and 4, which represent the body flattened on the shale.

*Observations.*—The living representatives of this beautiful little annelid are pelagic and very active swimmers; this fact and its association in the shale with small free swimming phyllopod crustaceans indicate very clearly that it was active and free swimming. Only three entire specimens were found.

*Formation and locality.*—Middle Cambrian: (35k) Burgess shale member of the Stephen formation on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) north-east of Burgess Pass, above Field, British Columbia.

## Class CHÆTOPODA

### SUB-CLASS POLYCHÆTA

#### MISKOA, new order

Polychæta with similar segments and parapodia throughout the length of the body; retractile proboscis; straight enteric canal. Body not distinctly specialized into sections.

#### MISKOIDÆ, new family

Body elongate, slender; with numerous uniform segments; anterior end with rows of strong setæ about the mouth. Surface of anterior portion with numerous papillæ. Parapodia abundant, branched. Proboscis elongate, retractile. Enteric canal straight, with enlargement in anterior portion.

*Observations.*—The long retractile proboscis with the mouth at its base (fig. 1) suggests the Class Gephyrea as does the large body

cavity surrounding the enteric canal, but the presence of distinct segments and parapodia brings *Miskoia preciosa* under the marine Polychæta. The constriction of the intestinal canal also suggests the Polychæta.

#### MISKOIA, new genus

The generic and specific description is united under the description of the species as there is but one species known.

*Genotype*.—*Miskoia preciosa*, new species.

*Stratigraphic range*.—The stratigraphic range is limited to a band of dark siliceous shale about 4 feet in thickness forming a part of the Burgess shale member of the Stephen formation.

*Geographic distribution*.—On the slope of the ridge between Wapta Peak and Mount Field, north of Burgess Pass, and about 3800 feet above Field on the line of the Canadian Pacific Railway, British Columbia, Canada.

Generic name derived from Misko, the name of a pass and creek south of Park Mountain and Lake O'Hara, British Columbia, Canada.

#### MISKOIA PRECIOSA, new species

Plate 18, figs. 1-5

Body elongate, slender. A specimen 26 cm. in length is 1 cm. in width at the widest part as it lies flattened in the shale. The body may be roughly divided into three sections: (1) The anterior, with the mouth and proboscis as shown in figs. 1 and 3; (2) the central, which is more or less expanded (fig. 2); (3) the slender, terminal section (fig. 5).

The anterior section merges into the central section so gradually that no definite line of demarcation can be drawn. There is a swelling posteriorly and a slight contraction anteriorly that at the end may be a simple opening fringed with fine strong setæ (fig. 1), or an expanded opening (fig. 3) with the setæ radiating from it. When the proboscis is protruded (fig. 1) the sides of the anterior section are nearly parallel, and when the proboscis is retracted the sides bulge outward. Usually the proboscis appears to have been cast off, in which case the body may contract between the mouth and the expanded central section. The central section may be considerably expanded or only a little larger, as shown by fig. 2, which is a portion of the specimen of which fig. 1 is the anterior and fig. 5 the posterior section.



The posterior section is a little more than one-third the entire length of the animal. Posteriorly it grows smaller and terminates in a rounded end.

*Surface.*—The surface of the anterior and central sections is marked by numerous distinct, annular, impressed lines that divide it into many segments or metameres. In a specimen 26 cm. in length the annular lines average two to the millimeter along the anterior half of the body (fig. 3), while the posterior half is apparently smooth (fig. 5). Numerous fine setæ occur on the posterior end of the body. The smooth surface may be due to the condition of preservation, as some specimens of the anterior half show no traces of annular rings or segments. From the mouth backward for a distance equal to four or five times the diameter of the flattened body the surface is thickly studded with elongated papillæ, as shown on the left side of figure 1. The papillæ appear to be arranged in longitudinal rows.

*Parapodia.*—Small, branching parapodia fringe the side of the body on several specimens (figures 4 and 5). There appear to be two, three, or even more divisions of some of the podia.

*Proboscis.*—A single specimen shows the proboscis protruded (fig. 1). It is slender and expanded toward the outer end where the surface is covered with numerous fine papillæ. The posterior half has many fine setæ extending obliquely forward. In fig. 3 the proboscis appears to have been retracted within the body and more or less crowded in on itself.

*Mouth and anus.*—The mouth is circular and surrounded by rows of strong setæ (figs. 1 and 3). No teeth have been seen. The anus is probably terminal as the enteric canal may be traced to within a very short distance of the posterior end of the body.

*Enteric canal.*—This canal is a rather large, elongated tube that extends from the mouth to the anus. It appears to be straight with an expansion at about the anterior third (fig. 2) that is quite marked in several specimens. In some examples the canal appears to be constricted by annular lines that divide it into segments two to three times as long as the segments of the body. There is a suggestion in one specimen that the body cavity was divided into a series of chambers by delicate muscular bands, but to be conclusive such an interpretation should be substantiated by evidence from other specimens.

*Observations.*—This beautiful annelid was first recognized from the specimen illustrated on pl. 18, figs. 1, 2 and 5. It was found

by Mrs. Walcott in splitting a slab of shale that had been slid down the mountain side and carried by pack animal to the Burgess Pass camp. We were all greatly interested and every one was on the alert to find other specimens. About ten days after the anterior half of the specimen represented by figs. 1 and 2 was found Mrs. Walcott called my attention to another "straight worm" she had found in a slab that had been blasted out of the ledge and taken to camp after the first discovery of the long annelid. I compared the two specimens and found that the break across them was on the same angle and that they fitted together to form the entire animal. Part of the second find is shown by fig. 5. The two parts united are 26 cm. in length. Subsequently several fragmentary specimens were found, but nothing equal to the specimen so strangely and fortunately saved by a most unusual combination of circumstances.

There are a number of unsolved questions relating to this annelid on which I will not now speculate, as the collection of 1911 may give further material for study.

*Formation and locality.*—Middle Cambrian: (35k) Burgess shale member of the Stephen formation; west slope of ridge between Mount Field and Wapta Peak, one mile northeast of Burgess Pass, above Field on the Canadian Pacific Railway, British Columbia, Canada.

#### AYSHEAIDÆ, new family

Polychæta with a slender fusiform body with many segments, large, strong, segmented parapodia attached to alternating groups of segments, setæ on parapodia as hoops or jointed spines. Head small with two and probably four tentacles.

*Observations.*—It would be hazardous to define a family of living Polychæta from the data afforded by *Aysheia pedunculata*, but it would be still more so to identify this strongly marked form with any of the described families. The peculiar segmentation of the body and the attachment of the large parapodia on alternating groups of segments are unusual. While it is not impossible, it is not probable that a Cambrian annelid of this type would belong to any of the families of recent annelids.

#### AYSHEAIA, new genus

Of this genus there is but one species and one specimen known. The generic and specific descriptions are combined under the species.

*Genotype.*—*Aysheia pedunculata*, new species.

*Stratigraphic range.*—The stratigraphic range is limited to a band of dark siliceous shale about 4 feet in thickness forming a part of the Burgess shale member of the Stephen formation.

*Geographic distribution.*—On the slope of the ridge between Wapta Peak and Mount Field, north of Burgess Pass, and about 3800 feet above Field on the line of the Canadian Pacific Railway, British Columbia, Canada.

Generic name derived from Ayshea, the name of a mountain peak north of Wapta glacier, British Columbia, Canada.

**AYSHEAIA PEDUNCULATA, new species**

Plate 23, figs. 8 and 9

Body elongate, slender. Segments numerous and clearly defined by lines on which many minute shallow pits occur, several of the lines having 13 pits on the exposed side of the body. Head small; a central narrow longitudinal section has a rounded lobe on each side of its posterior half that suggests large eyes; the anterior end appears to have two short, slender tentacles projecting forward. Parapodia large and attached in such a manner as to have two lines of pits and three segments between each pair of parapodia, and one line of pits and two segments between the lines of pits which merge into the anterior and posterior outline of each parapodia or foot. Hook-like and straight, jointed setæ are attached to the parapodia. Traces of a small enteric canal occur in the posterior half of the body.

*Dimensions.*—Length of specimen preserving 10 parapodia on the left side 33 mm. Width as flattened in the shale 3 to 4 mm. One parapodia is 3 mm. in length. Each one appears to be drawn in towards the body.

*Observations.*—The unique specimen representing this species is flattened and slightly distorted in the shale. The head is not as distinct as the body and some of the posterior portion is missing. In the hope of finding other specimens during the season of 1911 further discussion on its structure will be deferred. This species is associated with *Ottoia prolifica* (pl. 29, figs. 1-5).

*Formation and locality.*—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

**CANADIDÆ, new family**

Polychæta with a slender body formed of long segments bearing setiferous parapodia with dorsal and ventral bundles of setæ. Head small with two strong tentacles.

One genus, *Canadia*.

*Observations*.—For comparison with recent annelids we turn to the Aphroditidæ,<sup>1</sup> Amphinomidæ, and Palmyridæ, but in none of these do we find the slender body, narrow segments combined with the small parapodia, and great development of setæ without scales on the dorsal surface.

#### CANADIA, new genus

The description and illustrations of *Canadia spinosa* will serve to indicate this genus. The other species express, in variations in size and position of the bundles of setæ, characters that for this preliminary study are considered to be of specific value.

*Genotype*.—*Canadia spinosa*, new species.

*Stratigraphic range*.—The stratigraphic range is limited to a band of dark siliceous shale about 4 feet in thickness forming a part of the Burgess shale member of the Stephen formation.

*Geographic distribution*.—On the slope of the ridge between Wapta Peak and Mount Field, north of Burgess Pass, and about 3800 feet above Field on the line of the Canadian Pacific Railway, British Columbia, Canada.

*Observations*.—Five species are referred to *Canadia*: *C. spinosa*, *C. setigera*, *C. sparsa*, *C. dubia*, and *C. irregularis*. Of these the first two are illustrated on pl. 23. The other three species will be illustrated in a final paper on this fauna.

Generic name derived from Canada.

#### CANADIA SPINOSA, new species

Plate 23, figs. 4-7

Body slender, formed of 20 to 21 segments that, when flattened on the shale, are a little longer than wide; each segment has a pair of parapodia with a dorsal and ventral bundle of strong non-jointed setæ. The setæ are finely illustrated by figs. 4, 6, and 7. Head minute, with a pair of large tentacles curving outward from the front anterior margins; a bundle of fine setæ occurs on each side of the head back of the base of the large tentacles. A straight slender enteric canal is indicated on several specimens. Mouth and anus not seen, but probably at or near the end of the annelid.

*Dimensions*.—The largest adult specimen has a length of 34 mm., with a width of the body at the seventh segment from the head of 1.5 mm.

<sup>1</sup> See Dr. E. Ehlers beautiful memoir on the annelids of the Blake expedition. Mem. Mus. Comp. Zool., Vol. 15, 1887.

*Observations.*—This beautiful species recalls in its dorsal aspect the recent *Palmyra aurifera*<sup>1</sup> and *Cylavia euglochis* Ehlers.<sup>2</sup> The latter has almost the same grouping of setæ on the parapodia.

The species is represented by a number of specimens, but none exhibit the detailed structure of the head.

*Formation and locality.*—Middle Cambrian (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

#### CANADIA SETIGERA, new species

Plate 23, figs. 1-3

This species differs from *C. spinosa* in being more elongate, slender, and with much smaller bundles of finer setæ. Its characters are well illustrated by figs. 1 and 3. A series of 36 specimens indicate that the elongate forms represented by figs. 1 and 2 are connected by numerous gradations with the form represented by fig. 3.

*Formation and locality.*—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

#### CANADIA SPARSA, new species

A slender form with only two strong setæ on each very short parapodia. Finer setæ may occur, but they are not shown on the one specimen which, in size and distance of the parapodia, resembles the specimen represented by fig. 2, pl. 23.

*Formation and locality.*—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

#### CANADIA DUBIA, new species

This species is proposed to include a small chætiforous annelid not over 10 mm. in length. One specimen shows a bundle of very fine setæ on each side near the head.

*Formation and locality.*—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

<sup>1</sup> Challenger Rept. Zoology, Vol. 12, 1885, pl. 9, fig. 1.

<sup>2</sup> Mem. Mus. Comp. Zool., Vol. 15, 1887, pl. 1, fig. 1.

**CANADIA IRREGULARIS**, new species

A small slender species not over 20 mm. in length. The setæ are irregular in size and appearance and suggest partially worn macerated specimens of the slender forms of *C. setigera*.

*Formation and locality*.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) north-east of Burgess Pass, above Field, British Columbia.

**SELKIRKIA**, new genus

Polychæatous annelids with a slender, straight, or slightly curved tube. Probably chitinous. A number of tubes of *Selkirkia major* show the animal projecting from the end as illustrated by fig. 6, pl. 19. It is divided into segments or sections and more or less provided with short spines at the base of the anterior or end section. A number of short-jointed appendages indicate a rather large head.

*Genotype*.—*Selkirkia major* (Walcott).

Two other species *S. fragilis* and *S. gracilis* are referred to this genus on account of the form of the tubes; they are clearly not to be referred to *Hyalithes*.

*Stratigraphic range*.—The stratigraphic range is limited to a band of dark siliceous shale about 4 feet in thickness forming a part of the Burgess shale member of the Stephen formation at locality (35k) near Burgess Pass, and on the slope of Mount Stephen it was found extending through 50 feet or more of the coarse siliceous shales.

*Geographic distribution*.—On the slope of the ridge between Wapta Peak and Mount Field, north of Burgess Pass, and about 3800 feet above Field on the line of the Canadian Pacific Railway; and on the slope of Mount Stephen 2300 feet above Field; both in British Columbia, Canada.

Generic name derived from Selkirk, name of mountain range, British Columbia, Canada.

**SELKIRKIA MAJOR** (Walcott)

Plate 19, fig. 6

*Orthotheca major* WALCOTT, 1908, Canadian Alpine Journal, Vol. 1, p. 246, pl. 1, fig. 11.

This species was founded on a long, slender, delicate tube that is known only as it occurs flattened on the surface of the shale. The apical end is broken off on all the specimens in the collection. The

tube is usually so completely flattened that the fine concentric lines and fine ridges that give an annulated appearance to it have disappeared; often the tubes appear to be longitudinally striated as the result of lateral compression. Some tubes appear to be slightly constricted near the aperture and also a little thickened. The tubes were thin and easily compressed and flattened. They may have been calcareous, but from their bright, almost shiny, luster they were more probably chitinous or parchment-like.

*Dimensions.*—The largest flattened tube has a length of 68 mm., with a width of 12 mm. at the larger end, and of 8 mm. at the smaller. A more slender tube 64 mm. long is 9 mm. wide at the large end and 2 mm. at the smaller. The larger number of tubes have a transverse diameter of from 5 to 7 mm. at the larger end.

*Animal.*—Ten specimens show more or less of the animal projecting from the tube. It fills the end of the tube and is divided into sections a little longer than wide that are faintly indicated by slight successive contractions, and the presence of somewhat more prominent spines or hooks. The spines appear to have been arranged in concentric rows over all parts of the surface of the body except the terminal section. A specimen that is not illustrated shows a conical terminal section with several small-jointed appendages about its posterior end. My present impression is that the terminal section represents the head and the appendages a circle of gills. From the fact that the animal projects so much more from some tubes than it does from others, it seems that it was retractile and could withdraw into its tube. No traces of an operculum have been seen. With the somewhat formidable series of spines to protect it an operculum would scarcely have been necessary.

*Observations.*—On pl. 19, fig. 7, there is inserted for comparison with *Selkirkia major* a photograph of a specimen of *Hyalithes carinatus* Matthew showing the triangular tube, operculum, and, for the first time among the Hyolithidae, the curved supports of the fins of a pteropod.

The discovery of the animal that lived in one of the tubes that has been classed with the pteropods removes one more doubtful form from the latter to the annelids, and with it will probably go *Hyalithellus* and other tube-like shells that have none of the distinctive external characters of *Hyalithes* and its allies.

In these preliminary notes I do not care to mention further the relations of the various Paleozoic tube-like fossils that have been referred to the Pteropoda and Annelida, except to call attention to a

discussion of the subject by Dr. G. F. Matthew,<sup>1</sup> who concludes that *Hyalithes* and allied forms should be classed with the annelids, along with *Hyalithellus* and other slender tubes.

During the field season of 1911 we hope to add something more to the information about the animal of *Selkirkia*.

*Formation and locality*.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) north-east of Burgess Pass, above Field; and (14s) about 2300 feet (701 m.) above the Lower Cambrian and 2700 feet (823 m.) below the Upper Cambrian, in the Ogygopsis zone of the Stephen formation, at the great "fossil bed" on the northwest slope of Mount Stephen, above Field on the Canadian Pacific Railway; both in British Columbia, Canada.

#### SELKIRKIA FRAGILIS, new species

Plate 19, fig. 8

A thin tube that when flattened has a diameter at the larger end of from 2.5 to 3 times its length; the slender proximal end is curved. The largest specimen has a length of 25 mm. This species differs from *Selkirkia gracilis* (fig. 9), and *S. major* (fig. 6) in its greater proportional diameter at the aperture.

*Formation and locality*.—Middle Cambrian: (14s) about 2300 feet (701 m.) above the Lower Cambrian and 2700 feet (823 m.) below the Upper Cambrian, in the Ogygopsis zone of the Stephen formation, at the great "fossil bed" on the northwest slope of Mount Stephen, above Field on the Canadian Pacific Railway, British Columbia, Canada.

#### SELKIRKIA GRACILIS, new species

Plate 19, fig. 9

A number of fine specimens of this species have been found in the same layers of shale with *S. major*, but unfortunately none of them show any traces of the animal. The tube is very thin and, unlike *S. major*, retains the slender, more or less curved proximal end. A comparison of fig. 9 with figs. 6 and 8 shows how this flattened tube differs in form from *S. major* and *S. fragilis*.

The largest tube has a length of 47 mm. and a width of 10 mm. at the aperture.

<sup>1</sup>Trans. Roy. Soc., Canada, 2d ser., Vol. 5, sec. 4, 1899, p. 103.



*Formation and locality.*—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) north-east of Burgess Pass, above Field; and (14s) about 2300 feet (701 m.) above the Lower Cambrian and 2700 feet (823 m.) below the Upper Cambrian, in the Ogygopsis zone of the Stephen formation, at the great "fossil bed" on the northwest slope of Mount Stephen, above Field on the Canadian Pacific Railway; both in British Columbia, Canada.

#### WIWAXIDÆ, new family

Body oval; covered with dorsal ribbed scales and strong, elongate spines.

One genus, *Wiwaxia*.

#### WIWAXIA, new genus

The generic and specific descriptions are united under the description of the species.

*Genotype.*—*Wiwaxia corrugata* (Matthew).

*Stratigraphic range.*—The stratigraphic range is limited to a band of dark siliceous shale about 4 feet in thickness forming a part of the Burgess shale member of the Stephen formation at locality (35k) near Burgess Pass, and on the slope of Mount Stephen it was found in the trilobite beds of locality (14s).

*Geographic distribution.*—On the slope of the ridge between Wapta Peak and Mount Field, north of Burgess Pass, and about 3800 feet above Field on the line of the Canadian Pacific Railway; also on the slope of Mount Stephen 2300 feet above Field; both in British Columbia, Canada.

Generic name derived from *Wiwaxy*, name of several small mountain peaks north of Lake O'Hara, British Columbia, Canada.

#### WIWAXIA CORRUGATA (Matthew)

Plate 21, figs. 1-4

*Orthotheca corrugata* MATTHEW, 1899, Trans. Roy. Soc. Canada, 2d ser., Vol. 5, sec. 4, p. 42, pl. 1, fig. 3.

*Orthotheca corrugata* WALCOTT, 1908, Canadian Alpine Journal, Vol. 1, No. 2, p. 246, pl. 1, fig. 11.

This fine species is represented by a number of specimens of nearly the entire dorsal surface, which appears to have been covered by scales. The best example of what was probably the entire dorsal outline is illustrated by fig. 2, the anterior end being at the left or next to the side of the plate. The scales, as on the recent *Aphro-*

ditidæ and Polynoidæ, radiate or point from the axis of the body backward and outward along the sides. An example of a recent annelid covered with dorsal scales is furnished by *Iphionella cimex* De Quatref,<sup>1</sup> and dorsal spines are a distinctive character on *Lætmonice producta willemæsii*,<sup>2</sup> *L. producta wyvilli*,<sup>3</sup> and *Lætmonice aphrodites*.<sup>4</sup> The form, size, and surface markings of the scales and spines of *Wiwaxia* are well shown by the illustrations on pl. 21. In fig. 4 the slender cylindrical proximal extension of the end of the scale and also of the dorsal spines is well shown; this extension probably continued down into the sac from which the scale began its growth. The spines are probably modified scales, but they may correspond to the dorsal spines of the recent annelids referred to above. A very fine surface ornamentation consisting of minute, irregularly outlined, transversely oblong spaces also occurs on the scales. The scattered scales and spines are often very abundant. It was one of the spines that Dr. G. F. Matthew described under the name of *Orthotheca corrugata*.<sup>5</sup> It is hoped that specimens showing the ventral surface of the animal will be found in the near future.

*Formation and locality*.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) north-east of Burgess Pass, above Field; and (14s) about 2300 feet (701 m.) above the Lower Cambrian and 2700 feet (823 m.) below the Upper Cambrian, in the Ogygopsis zone of the Stephen formation, at the great "fossil bed" on the northwest slope of Mount Stephen, above Field on the Canadian Pacific Railway; both in British Columbia, Canada.

#### POLLINGERIA, new genus

The generic and specific characters known are given under the description of the species.

*Genotype*.—*Pollingeria grandis*, new species.

*Stratigraphic range*.—The stratigraphic range is somewhat greater than that of *Wiwaxia corrugata*, with which it is associated in some layers. The scales have been found extending up from the Phyllopod bed (page 130) through about 30 feet of shale.

<sup>1</sup> Challenger Rept. Zool., Vol. 12, 1889, pl. 9, fig. 4.

<sup>2</sup> Idem, pl. 6, fig. 3.

<sup>3</sup> Idem, pl. 7, fig. 3.

<sup>4</sup> Idem, pl. 7, fig. 4.

<sup>5</sup> Trans. Roy. Soc., Can., 2d ser., Vol. 5, sec. 4, 1899, p. 42, pl. 1, fig. 3.

*Geographic distribution.*—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) north-east of Burgess Pass, above Field, British Columbia.

Generic name derived from Pollinger, name of mountain of President range, British Columbia, Canada.

**POLLINGERIA GRANDIS**, new species

Plate 21, figs. 7, 8, and 9

This is a much larger form than *Wiwaxia corrugata*. One specimen that has the anterior end broken off measures 12 cm. in length, with a width midway of 7 cm. Individual scales vary in length from 10 to 15 mm. The scales are thin, smooth, elongate, and variable in outline as shown by figs. 7-9. They occur in great numbers scattered on the surface of partings of the shale, but in only one example are they grouped together to indicate the size and form of the dorsal surface. Nothing is known of the body of the annelid.

One of the curious facts connected with the scales is that a considerable proportion of them have been traversed by a minute annelid, the trail of which curves and coils about within the area of the scale. This indicates that there was some animal matter attached to the scale which the minute annelid was seeking.

The scales of this species are so radically different from those of *Wiwaxia* that they do not fall within that genus. There are no dorsal spines so far as known.

The presence of two or three other species of annelids is shown by the presence of scales that vary materially from those of *Pollingeria grandis* and *Wiwaxia corrugata*.

*Formation and locality.*—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) north-east of Burgess Pass, above Field, British Columbia.

**WORTHENELLA**, new genus

As this genus has but one known species the description of the latter will sufficiently define the genus.

*Genotype.*—*Worthenella cambria*, new species.

*Stratigraphic range.*—The stratigraphic range is limited to a band of dark siliceous shale about 4 feet in thickness forming a part of the Burgess shale member of the Stephen formation.

*Geographic distribution.*—On the slope of the ridge between Wapta Peak and Mount Field, north of Burgess Pass, and about 3800 feet above Field on the line of the Canadian Pacific Railway, British Columbia, Canada.

*Observations.*—The generic name is given in recognition of the fine work of Prof. A. H. Worthen, formerly State Geologist of Illinois.

**WORTHENELLA CAMBRIA, new species**

Plate 22, fig. 2

Body slender, elongate, and formed of 46 or more segments and a small head. The segments, as flattened in the shale, have a length of about one-half the diameter, which indicates that when uncompressed the diameter and length of each segment were about the same. Each segment has an annular median furrow that serves to divide it into two narrow rings with a groove between them.

The head is not well-preserved, but it appears to be formed of a large posterior segment and one or two anterior segments. A small shiny spot in front suggests an eye. The head appears to have been conical in form and provided with one or more pairs of tentacles and a pair of palps, the latter being represented by the long filament-like organs extending back from the ventral side of the head. The tentacles are represented by short, faint, jointed appendages extending forward from the front of the head.

The anterior 34 segments of the body show on their inner or ventral side, as compressed on the shale, strong parapodia divided into two filamentous branches. The parapodia of the next posterior 8 segments are longer and more compact. This description of the parapodia is subject to revision as the details of structure are not clear.

*Enteric canal.*—A very narrow dark line that extends close to the ventral or inner margin of the body from the head nearly to the posterior end, may represent a slender enteric canal.

*Measurements.*—The only specimen in the collection has a length of about 60 mm.

*Observations.*—Of this species there is only one specimen and its matrix. The characters described are readily seen by reflected light. The presence of small oval and round scale-like objects on the shale suggests that they may have belonged to the annelid and been detached. If so, with our present information *Worthenella cambria* is considered to represent an annelid belonging to the order Polychæta. It does not appear to fall within the limits of any of the recent families of the order. It may be that in the collections of

1911 material will be discovered that will give much better data for determining its family relations.

*Formation and locality.*—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, west slope of ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field on the Canadian Pacific Railway, British Columbia, Canada.

### Class GEPHYREA—Quatrefages

#### Class II.—GEPHYREA.

“The Gephyrea are marine Annulata devoid of any trace of segmentation in the adult condition, without parapodia, and either without setæ or with only a limited number; with either an invaginable anterior body region or introvert, at the extremity of which is the mouth surrounded by tentacles, or with a long, highly retractile proboscis representing the pre-oral lobe of the larva, and having the mouth situated at the base. The anus is sometimes terminal and posterior, sometimes anterior and dorsal. There is an extensive cœlome filled with a corpusculated fluid, and not divided by septa. The ventral nerve-cord is not made up of a series of ganglia. There is, as a general rule, only a single pair of nephridia. The sexes are separate; the ovaries and testes simple masses of cells; the nephridia act as reproductive ducts. The larva is a trochophore.”<sup>1</sup>

The genus *Ottoia* is tentatively referred to the Gephyrea, since, while it possesses certain characters of the Gephyrea, it has others that do not come clearly within the class. The segmentation of the body serves to withdraw it from Gephyrea, but in so ancient a form this character is to be anticipated. The proboscis is similar in function to that of some of the Gephyrea and Polychæta where the buccal region is “*everted*” and may be withdrawn into the buccal region.<sup>2</sup> The proboscis and mouth of *Ottoia* also suggest the sucker-like mouth and proboscis of some of the Hirudinea (leeches). The exterior appearance of the body of *Ottoia* is also not unlike that of some of the leeches that have a slender body, finely marked segmentation, and a retractile proboscis with the mouth at the end. The absence of parapodia removes *Ottoia* from the Polychæta, and the presence of segments is not sufficient to place it with the Hirudinea.

<sup>1</sup> Parker and Haswell, Text-Book of Zoology, Vol. 1, London, 1910, pp. 491-492.

<sup>2</sup> See Cambridge Natural History, Vol. 2, London, 1806, pp. 249-250.

## ORDER?

With our present information it is not practicable to make a reference of *Ottoia* to any of the existing orders of the Gephyrea. The presence of an anterior, retractile, or introvertible proboscis, and the elongate cylindrical shape of the body is essentially similar to some of the Sipunculoidea, but the direct enteric canal, and more or less distinct segmentation is unknown in that order. In this tentative study the ordinal classification will be omitted.

## OTTOIDÆ, new family

Body cylindrical, elongate; with numerous segments that vary in width posteriorly. Hooks about the mouth and also at the posterior end. Proboscis papillose, introvertible, and with mouth at anterior end. Enteric canal direct from mouth to anus, or possibly with some slight convolutions.

The genus *Ottoia* is referred to this family, and also, though tentatively, *Banffia*.

## OTTOIA, new genus

The description of the species *O. prolifica* includes all the known essential characters of the genus.

*Genotype*.—*Ottoia prolifica*, new species.

*Stratigraphic range*.—The stratigraphic range is limited to a band of dark siliceous shale about 4 feet in thickness forming a part of the Burgess shale member of the Stephen formation.

*Geographic distribution*.—On the slope of the ridge between Wapta Peak and Mount Field, north of Burgess Pass, and about 3800 feet above Field on the line of the Canadian Pacific Railway, British Columbia, Canada.

*Observations*.—The position of *Ottoia* among the annelids is discussed under the class Gephyrea to which it is tentatively referred (page 127).

Generic name derived from Otto, name of a creek north of President Range, British Columbia, Canada.

## OTTOIA PROLIFICA, new species

Plate 19, figs. 1-5

Body elongate, tapering at each end when not contracted. It is divided by annular lines into many segments that average seven in a distance of 5 mm., except toward the posterior end where they are about twice as long (fig. 5). At the anterior end there is a band of

minute hooks arranged in five or six concentric rings (figs. 1, 2, 4, and 5). At the posterior end there is a concentric row of stronger hooks as shown by figs. 1 and 3.

The proboscis is strong, retractile, and papillose. In fig. 4 it is extended nearly to its full length; in figs. 1 and 5 partially contracted, and in fig. 2 apparently broken off.

There are no traces of parapodia or openings on the surface except at the ends of the body.

Enteric canal small and extending the entire length of the body from the mouth to the posterior end (fig. 2). The mouth is at the base of the proboscis in front of the bands of hooks (fig. 2). The anus appears to have been at the posterior end, as indicated by the termination of the enteric canal in figs. 1 and 2.

The average length of adult specimens is from 8 to 10 cm. One 9 cm. in length is 2 cm. across its widest part as it is flattened in the shale. Other specimens are more contracted, shorter, and proportionally broader (fig. 1).

*Observations.*—There is a large series of this species in various conditions of preservation. Some show the annular lines and bands with great distinctness (figs. 1 and 3) and others are apparently smooth (fig. 2). The proboscis may be protruded (fig. 4), partially pushed out (fig. 5), or absent (fig. 2). Bands of longitudinal muscles are suggested by the lines near the inner curve of fig. 1, and concentric muscles by the annular bands.

*Formation and locality.*—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, west slope of ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field on the Canadian Pacific Railway, British Columbia, Canada.

#### OTTOIA MINOR, new species

Plate 22, figs. 5 and 6

This species differs from *Ottoia prolifica* in its proportionally more slender form when elongated (fig. 5), and straighter outline both when elongated and contracted (fig. 6). The hooks are also much finer and extend farther back on the anterior end. The annular lines and interspaces are also finer and more irregular.

*Formation and locality.*—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, west slope of ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field on the Canadian Pacific Railway, British Columbia, Canada.

**OTTOIA TENUIS**, new species

This species is based on a small slender annelid that has a slender proboscis; its anterior end has a band of hooks and the posterior end a long whip-like appendage that is longer than the body. The body, exclusive of the caudal appendage, is from 25 to 30 mm. in length in the four specimens collected. One 30 mm. long has a width of 2 to 2.5 mm. as it flattened in the shale.

*Ottoia tenuis* differs from *O. prolifica* and *O. minor* in its slender body and long posterior appendage.

*Formation and locality.*—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

**BANFFIA**, new genus

The description of the type species includes all that is known of the genus.

*Genotype.*—*Banffia constricta*, new species.

*Stratigraphic range.*—The stratigraphic range is through about 110 feet of shale or from the lower Phyllopod bed,<sup>1</sup> where it occurs in a hard siliceous shale, up through to nearly the summit of the Burgess shale where the shale is coarser-grained, steel gray in color on fresh surface, and weathering to a dirty buff color.

*Geographic distribution.*—On the slope of the ridge between Wapta Peak and Mount Field, north of Burgess Pass, and about 3800 feet above Field on the line of the Canadian Pacific Railway, British Columbia, Canada.

*Observations.*—The reference of this genus to the Gephyrea is tentative. With its elongate body and annular lines it resembles *Ottoia*, and in the absence of interior structure the evidence is too incomplete to refer it elsewhere.

Generic name derived from Banff, name of town on Canadian Pacific Railway, Alberta, Canada.

**BANFFIA CONSTRICTA**, new species

Plate 21, figs. 5 and 6

Body elongate, constricted midway. The anterior and larger section is elongate-spatulate in outline and the posterior section a narrow ellipse truncated at the ends. The constriction between the

<sup>1</sup> Phyllopod bed is the name now given to a stratum of shale about 5 feet in thickness in the Burgess shale in which many Phyllopod crustaceans occur.



two sections reduces the diameter at that point, of a specimen flattened in the shale, to one-half the cross section of the anterior portion.

Surface of anterior section marked by fine, transverse, slightly imbricating lines that serve to define narrow segments. On a specimen 55 mm. in length there are 4 lines in a distance of 5 mm.; in one 10 mm. long, 7 to 8 in 5 mm.

The posterior section has more and stronger lines than the anterior section. The distance between them varies according to the extent to which the annelid was drawn up or contracted. The distance also varies in different parts of the section, but usually they are farther apart near the ends. On a posterior section 35 mm. in length the lines on the posterior third are 1 mm. apart and on the central and anterior portion .5 mm. distant. On one specimen two rather strong hooks occur at the posterior end. No traces of a mouth or anus have been observed. One fragment shows a small enteric canal.

*Dimensions.*—The largest specimen of the half dozen in the collection has a length of 8 cm. A fragment of another indicates a length of 10 cm.

*Observations.*—This interesting species occurs in a somewhat coarser sediment than the annelids *Ottoia prolifica* and *Miskoia preciosa* with the result that the more delicate parts have not been preserved. It is hoped that the collections of 1911 may afford better specimens.

*Formation and locality.*—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, west slope of ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field on the Canadian Pacific Railway, British Columbia, Canada.

#### PIKAIDÆ, new family

Polychæta with a slender, many segmented, mobile body; small head, with well-developed eyes; parapodia on the anterior segments. Enteric canal straight; mouth and anus at the ends of the body.

One genus, *Pikaia*.

#### PIKAIA, new genus

The description of the genus and species is united under the species.

*Genotype.*—*Pikaia gracilens*, new species.

*Stratigraphic range.*—The stratigraphic range is limited to a band of dark siliceous shale about 4 feet in thickness forming a part of the Burgess shale member of the Stephen formation.

*Geographic distribution.*—On the slope of the ridge between Wapta Peak and Mount Field, north of Burgess Pass, and about 3800 feet above Field on the line of the Canadian Pacific Railway, British Columbia, Canada.

Generic name derived from Pika, name of a mountain peak northwest of Laggan, Alberta, Canada.

**PIKAIA GRACILENS, new species**

Plate 20, figs. 1 and 2

Body elongate, slender, and tapering at each end. It is formed of many segments that are defined by strong annular shiny lines. Head small with two large eyes and two tentacles as shown by fig. 1. Back of the head the first five segments carry short parapodia that appear to be divided into two parts.

The enteric canal extends from end to end without change in character. It is relatively large along the central portions and tapering toward the ends. Judging from such specimens as the one illustrated by fig. 2, its annulations correspond in size with those of the body.

Surface apparently smooth. Two entire adult specimens and several fragments of others indicate a length of about 5 cm.

*Observations.*—This was one of the active, free-swimming annelids that suggest the Nephthydidæ of the Polychæta. I am unable to place it within any of the families of the Polychæta, owing to the absence of parapodia on the body segments back of the fifth. As compressed in the shale the study of a number of specimens of the posterior portion of the body leads me to think that it may have been flattened and thus been a much more effective aid in swimming.

*Formation and locality.*—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.

**OESIA, new genus**

Polychæta with thin, translucent, irregular tube having an enlarged head region. Segments numerous and more or less distinctly shown for the entire length. Enteric canal small and extending the length of the body. Hooks of anterior region very small.

Compared with recent annelids *Oesia* resembles some of the *Maldanidæ*.<sup>1</sup> In the absence of the details of head structure, setæ, etc., it is not practicable to compare the genera, although *Nicomache japonica*<sup>2</sup> looks as though it might appear very much like *Oesia disjuncta* if it were flattened out on a smooth surface.

*Genotype*.—*Oesia disjuncta*, new species.

*Stratigraphic range*.—The stratigraphic range is limited to a band of dark siliceous shale about 4 feet in thickness forming a part of the Burgess shale member of the Stephen formation.

*Geographic distribution*.—On the slope of the ridge between Wapta Peak and Mount Field, north of Burgess Pass, and about 3800 feet above Field on the line of the Canadian Pacific Railway, British Columbia, Canada.

Generic name derived from Oesa, name of a lake east of Lake O'Hara, British Columbia, Canada.

#### OESIA DISJUNCTA, new species

Plate 20, figs. 3-5

All this is known of this species is illustrated by the figures on Pl. 20. It appears to have been a form that lived in an irregular tube that was so thin the annelid shows through it. The segmentation is shown by fig. 3, and the enteric canal in the three specimens illustrated and several others in the collection. The variation in appearance is very great. No two specimens are alike. Traces of minute hooks at the anterior end have been observed on one specimen.

The largest specimen has a length of 10 cm., with a relatively small head.

*Formation and locality*.—Middle Cambrian: (35k) Burgess shale member of the Stephen formation, west slope of ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field on the Canadian Pacific Railway, British Columbia, Canada.

<sup>1</sup> Challenger Rept. Zool., Vol. 12, 1885, pls. 46 and 47.

<sup>2</sup> Idem, pl. 46, fig. 5.

## DESCRIPTION OF PLATE 18

## Legend:

e=enteric canal.  
m=mouth  
p=papillæ.

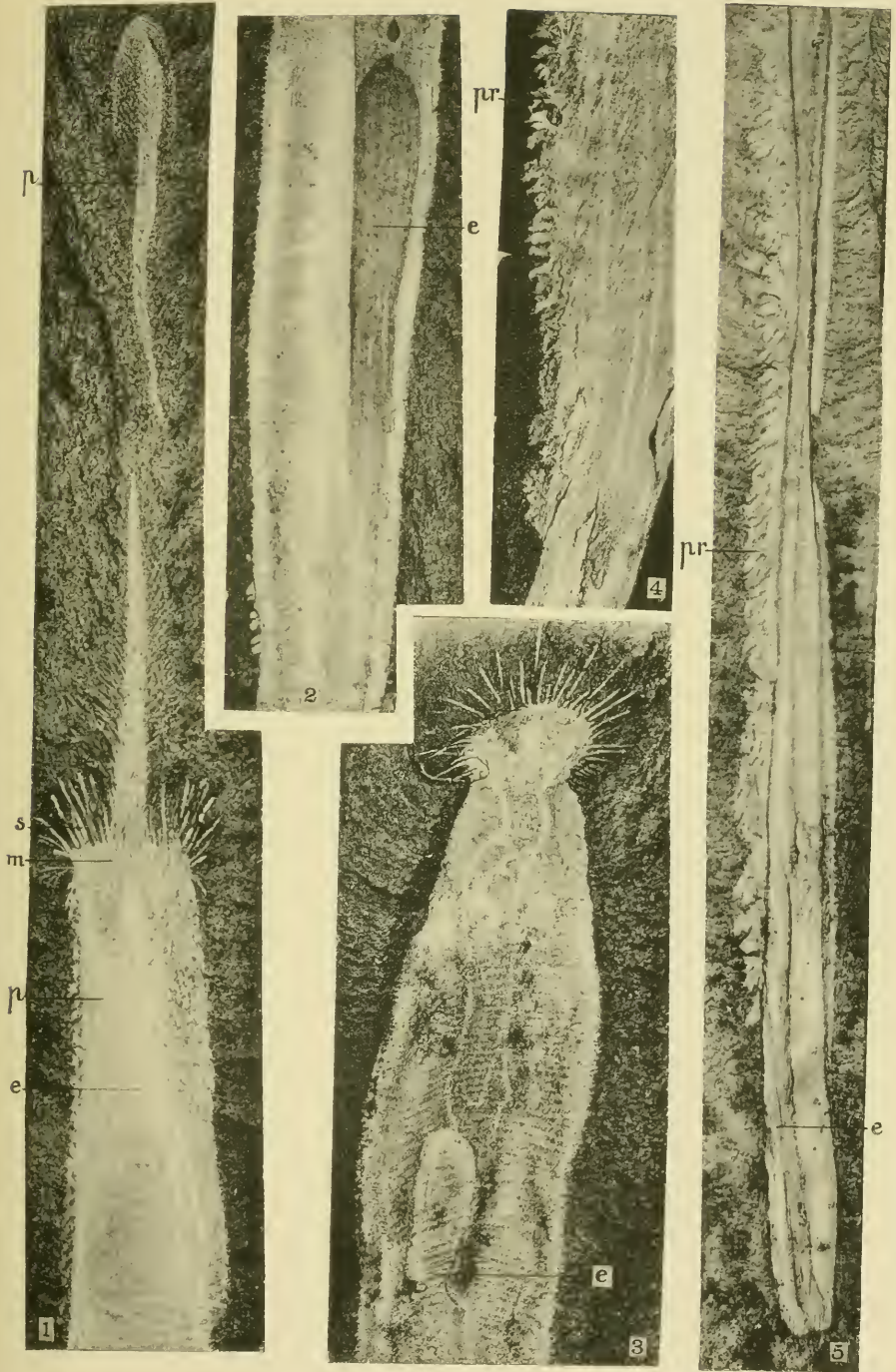
pr=parapodia.  
s=setæ.

## PAGE

*Miskoia preciosa* Walcott..... 114

- FIG. 1. (X 2.) Anterior portion of a specimen 26 cm. in length. The extruded proboscis is 5.5 cm. in length. The proboscis is broken midway by a slight displacement of the shale. The enteric canal is shown extending inward from the base of the proboscis. U. S. National Museum. Catalogue No. 57616.
2. (X 2.) Portion of the body of the specimen of figure 1, beginning 6 cm. back of the mouth or anterior end, showing the enlargement of the enteric canal.
  3. (X 2.) Anterior end of a body 9 cm. in length in which the proboscis appears to have been withdrawn. Setæ about the mouth, annular lines, and segments finely shown. U. S. National Museum, Catalogue No. 57617.
  4. (X 2.) Portion of a body showing the parapodia on left side. U. S. National Museum, Catalogue No. 57618.
  5. (X 2.) Nine (9) centimeters in length of terminal portion of annelid, the anterior portion of which is represented by figure 1. The parapodia are finely shown on the left side.

All of the specimens illustrated on this plate are from locality (35k) Middle Cambrian: dark siliceous shales in the Burgess shale member of the Stephen formation on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.



MIDDLE CAMBRIAN ANNULATA



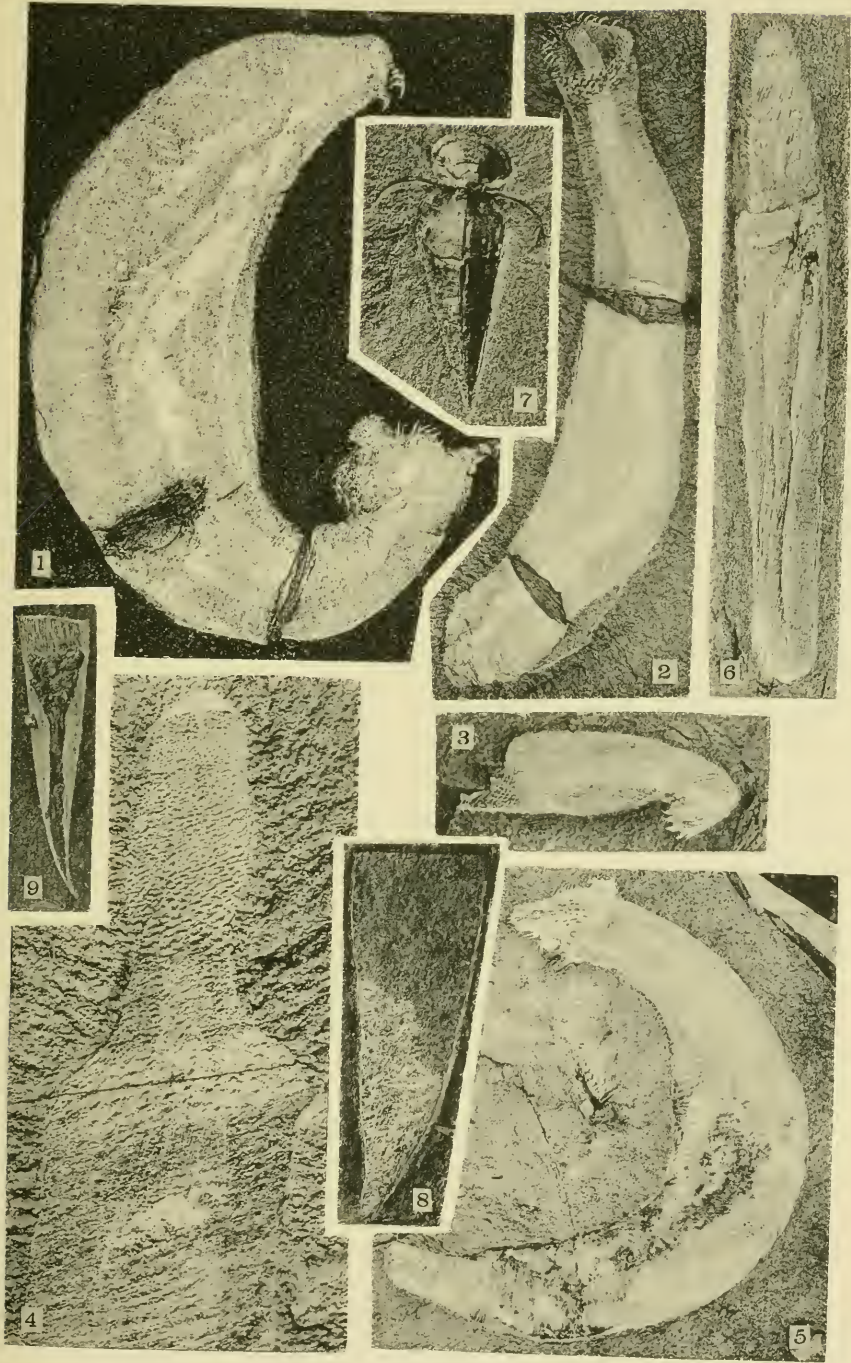


## DESCRIPTION OF PLATE 19

	PAGE
<i>Ottoia prolifica</i> Walcott.....	128
FIG. 1. (X 2.) A small specimen enlarged to show the hooks about the mouth, proboscis, and posterior end, also the distinct annular lines and segments. U. S. National Museum, Catalogue No. 57619.	
2. (Natural size.) An adult annelid showing the enteric canal and mouth, with the proboscis broken off. U. S. National Museum, Catalogue No. 57620.	
3. (X 2.) Posterior end of a small specimen in which the annular lines and hooks are very distinct. U. S. National Museum, Catalogue No. 57621.	
4. (X 3.) Enlargement of a proboscis, belt of hooks, and a portion of the anterior end of the body. The outlines of the enteric canal are clearly defined as well as the belt of hooks and the papillæ on the proboscis. U. S. National Museum, Catalogue No. 57622.	
5. (Natural size.) Adult annelid preserving very distinctly the annular lines and segments, ring of hooks, and proboscis. U. S. National Museum, Catalogue No. 57623.	
<i>Selkirkia major</i> (Walcott).....	120
FIG. 6. (X 3.) A flattened tube with the anterior portion of the animal projecting from it. U. S. National Museum, Catalogue No. 57624.	
<i>Hyolithes carinatus</i> Matthew.....	121
FIG. 7. (X 2.) Ventral view of shell, operculum and fin or arm supports. This is one of a number of specimens showing the curved fin supports. U. S. National Museum, Catalogue No. 57625.	
<i>Selkirkia fragilis</i> (Walcott).....	122
FIG. 8. (X 2.) Typical form of the tube as it is flattened in the shale of locality (14s) Middle Cambrian: about 2300 feet (701 m.) above the Lower Cambrian and 2700 feet (823 m.) below the Upper Cambrian, in the Ogygopsis zone of the Stephen formation, at the great "fossil bed" on the northwest slope of Mount Stephen, above Field on the Canadian Pacific Railway, British Columbia, Canada. U. S. National Museum, Catalogue No. 57626.	
<i>Selkirkia gracilis</i> (Walcott).....	122
FIG. 9. (Natural size.) Type specimen, flattened in the shale. U. S. National Museum, Catalogue No. 57627.	

With the exception of fig. 8, all of the specimens illustrated on this plate are from locality (35k) Middle Cambrian: dark siliceous shale in the Burgess shale member of the Stephen formation on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.





MIDDLE CAMBRIAN ANNULATA

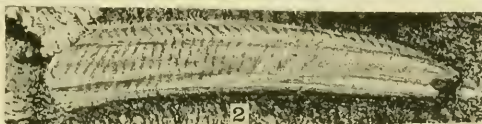




## DESCRIPTION OF PLATE 20

	PAGE
<i>Pikaia gracilens</i> Walcott.....	132
FIG. 1. (× 2.) A specimen flattened in shale, that shows the head, parapodia, segmentation, and outline of enteric canal. U. S. National Museum, Catalogue No. 57628.	
2. (× 2.) Fragments of a portion of the body. U. S. National Museum, Catalogue No. 57629.	
<i>Oesia disjuncta</i> Walcott.....	133
FIG. 3. (× 2.) Specimen showing annulations and enlarged anterior end. U. S. National Museum, Catalogue No. 57630.	
4. (× 2.) Specimen with irregular sections. U. S. National Museum, Catalogue No. 57631.	
5. Natural size. A nearly straight specimen with relatively small anterior end. U. S. National Museum, Catalogue No. 57632.	

All of the specimens illustrated on this plate are from locality (35k) Middle Cambrian: dark siliceous shales in the Burgess shale member of the Stephen formation on the west slope of the ridge between Mount Field and Wapta Peak, one mile (1.6 km.) northeast of Burgess Pass, above Field, British Columbia.



MIDDLE CAMBRIAN ANNULATA



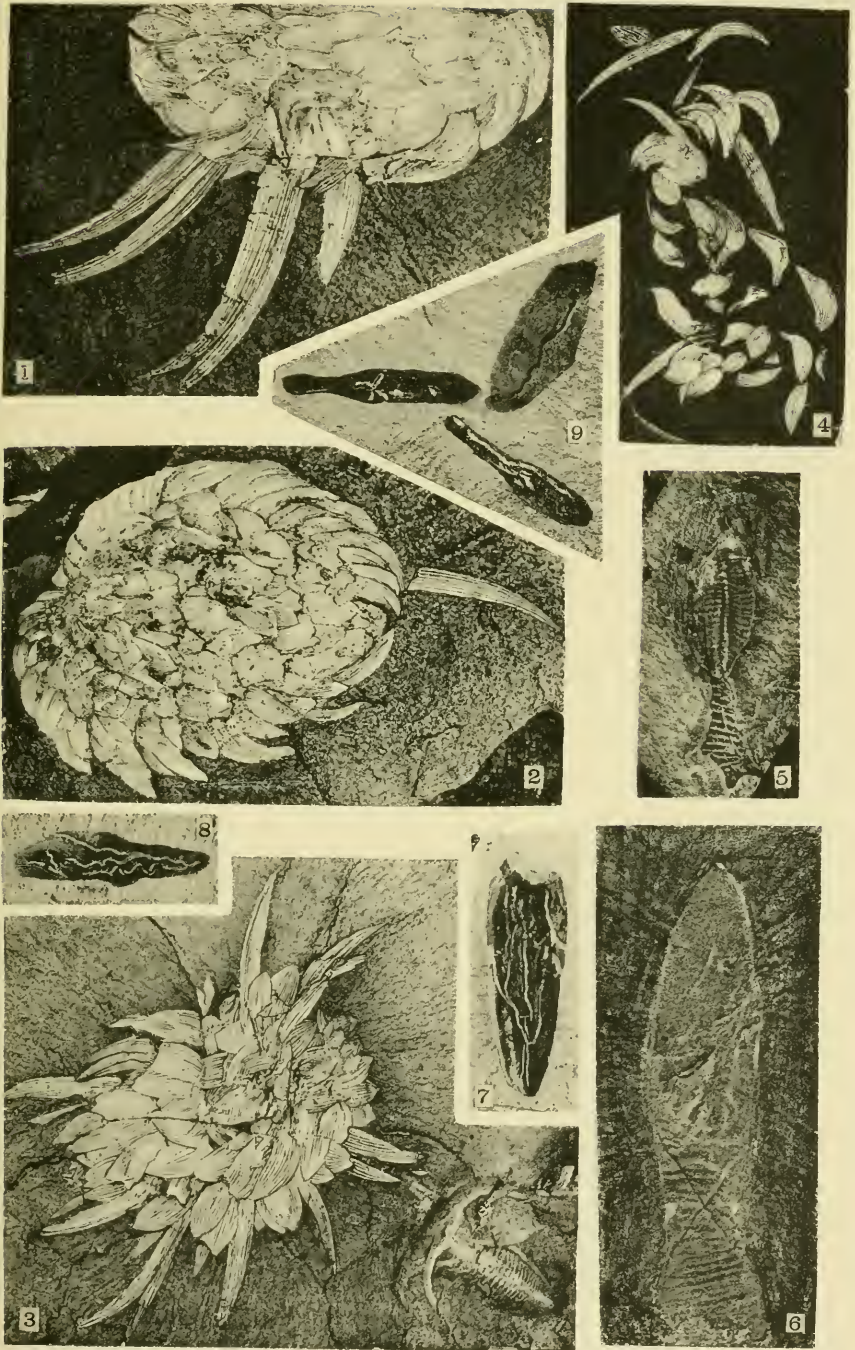


## DESCRIPTION OF PLATE 21

	PAGE
<i>Wiwaxia corrugata</i> (Matthew).....	123
FIG. 1. ( $\times 2$ .) Portion of the dorsal surface with numerous scales and five of the dorsal spines. U. S. National Museum, Catalogue No. 57633.	
2. ( $\times 2$ .) Dorsal surface. The arrangement of the scales indicates that the anterior end was on the left side where the outline is slightly incurved. U. S. National Museum, Catalogue No. 57634.	
3. ( $\times 1.25$ .) A specimen crushed down so as to displace scales and spines. U. S. National Museum, Catalogue No. 57635.	
4. (Natural size.) Scattered scales and spines on surface of shale. U. S. National Museum, Catalogue No. 57636.	
<i>Banffia constricta</i> Walcott.....	130
FIG. 5. (Natural size.) A small specimen showing the two sections of the body. U. S. National Museum, Catalogue No. 57637.	
6. (Natural size.) Anterior section and constriction with a portion of the posterior section. U. S. National Museum, Catalogue No. 57638.	
<i>Pollingeria grandis</i> Walcott.....	125
FIG. 7. ( $\times 2$ .) One of the larger scales. U. S. National Museum, Catalogue No. 57639.	
8. ( $\times 2$ .) Scale furrowed by minute annelid. U. S. National Museum, Catalogue No. 57640.	
9. ( $\times 2$ .) Scales differing in form. U. S. National Museum, Catalogue No. 57641.	

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MIDDLE CAMBRIAN ANNULATA





## DESCRIPTION OF PLATE 22

	PAGE
<i>Planolites</i> sp. ?	
FIG. 1. (Natural size.) Portion of a trail associated with <i>Ottoia prolifica</i> (pl. 19) illustrating a very common type of trail in the Burgess shale. U. S. National Museum, Catalogue No. 57642.	
<i>Worthenella cambria</i> Walcott.....	126
FIG. 2. ( $\times 2$ .) The type specimen as it occurs flattened on shale. U. S. National Museum, Catalogue Nos. 57644 and 57645.	
<i>Amiskwia sagittiformis</i> Walcott.....	112
FIGS. 3 and 4. ( $\times 3$ .) Flattened specimens described in the text. U. S. National Museum, Catalogue Nos. 57644 and 67645.	
<i>Ottoia minor</i> Walcott.....	129
FIG. 5. ( $\times 2$ .) An elongated specimen that occurs flattened on the shale. U. S. National Museum, Catalogue No. 57646.	
6. ( $\times 2$ .) A small contracted specimen. U. S. National Museum, Catalogue No. 57647.	

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## DESCRIPTION OF PLATE 23

- |   | PAGE |
|---|------|
| <i>Canadia setigera</i> Walcott.....  | 119  |
| FIG. 1. (× 2.) A slender flattened specimen showing bundles of setæ and one of the tentacles of the head on the left end. U. S. National Museum, Catalogue No. 57648.                                       |      |
| 2. (× 2.) Posterior portion of a slender specimen. U. S. National Museum, Catalogue No. 57649.  |      |
| 3. (× 3.) A specimen that is contracted more than those represented by figures 1 and 2. This brings the parapodia with their bundles of setæ nearer each other. U. S. National Museum, Catalogue No. 57650. |      |
| <i>Canadia spinosa</i> Walcott.....   | 118  |
| FIG. 4. (× 2.) Lateral view of a specimen flattened in the shale. U. S. National Museum, Catalogue No. 57651.   |      |
| 5. (× 3.) Anterior portion and head from the ventral side. U. S. National Museum, Catalogue No. 57652.  |      |
| 6. (× 2.) Ventral view of anterior portion and head showing segments of body, parapodia, and bundles of setæ. U. S. National Museum, Catalogue No. 57653.   |      |
| 7. (× 2.) Dorsal view showing dorsal setæ and bundles of projecting ventral setæ; also the head and tentacles. U. S. National Museum, Catalogue No. 57654.  |      |
| <i>Aysheaia pedunculata</i> Walcott.....  | 117  |
| FIG. 8. (× 2.) The type specimen as it occurs lying beside a specimen of <i>Ottoia prolifica</i> . (See pl. 19.) U. S. National Museum, Catalogue No. 57655.  |      |
| 9. (× 4.) Anterior portion of fig. 8, enlarged to show more detail.   |      |

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