ART. XVIII.—*Outline of a Natural Classification of the Trilobites*; by CHARLES E. BEECHER. (With Plate III.)

[Continued from page 106.]

Arrangement of the Families of Trilobites.

SUBCLASS TRILOBITA.

Order A. HYPOPARIA.

Family 1. Agnostidæ.	Family 3. Trinucleidæ.
Family 2. Harpedidæ.	

Order B. OPISTHOPARIA.

Family 4. Conocoryphidæ.	Family 8. Bronteidæ.
Family 5. Olenidæ.	Family 9. Lichadidæ.
Family 6. Asaphidæ.	Family 10. Acidaspidæ.
Family 7. Proëtidæ.	

Order C. PROPARIA.

Family 11. Encrinuridæ.	Family 13. Cheiruridæ.
Family 12. Calymenidæ.	Family 14. Phacopidæ.

The order Opisthoparia, with nearly one hundred and fifty genera, has a much greater geological distribution than either of the others, and was by far the dominant group during the Cambrian and Ordovician, being represented by about eighty-five genera in the former age and forty-five in the latter. Nineteen genera of this order are found in the Silurian and ten in the Devonian, most of them having continued on from older ages. Four genera represent the order in the Carboniferous and one in the Permian, thus marking the extinction of the subclass as well as the last genera of the Opisthoparia.

The comparative abundance and duration of the three orders are expressed in the table on page 182, from which it appears that the Hypoparia probably culminated in pre-Cambrian times, the Opisthoparia during the Cambrian, and the Proparia during the Ordovician.

In the following classification, the families adopted by Salter³³ and Barrande³ are in the main adhered to, and the number corresponds very closely with that in Zittel's "*Handbuch der Palæontologie*"³⁵ and also in the "*Grundzüge*"³⁶ of the same author. The order of arrangement, however, is very different. A great number of family divisions have been proposed, and undoubtedly many others will yet be made, but it is not within the province of this paper to determine the precise value and

limitations of the families. This would require discussions of priority and synonymy, and otherwise detract from the direct purpose of the writer; viz., to establish a basis for a natural classification, and in this way to apply what is currently known and accepted regarding the trilobites. Nevertheless, some notice must be taken of several families and genera which for various reasons do not appear here. The family Aglaspidæ, including the genus *Aglaspis* Hall, proves to belong to the Merostomata, and is therefore omitted. The family Bohemilidæ has been shown by the writer^a to have no foundation, because the type of the genus *Bohemilla* Barrande was based upon a mutilated specimen of *Eglina*.

Table of Geological Distribution of Trilobites.

Several genera still commonly adopted are not here recognized in the lists under the families, since from the minute size of the individuals described and their immature characters, they must be considered as the young of larger forms. Such are *Conophrys* Callaway, *Cyphoniscus* Salter, *Holometopus* Angelin, *Isocolus* Angelin, and *Shumardia* Billings. *Triopus* Barrande has been shown to be a chiton.

Much could be said against some of the recognized genera, but, as with the families, the writer has preferred in almost every case to adopt, for the present, what has been commonly accepted, and thus to avoid the entanglements of dates and synonyms which would be out of place in any general discussions. The type species of every genus is here made the central idea. It is taken as representing the genus more closely than any fortuitous assemblage of diverse species, which the

next investigator may show belong to another or to several genera. Our ideas of a genus are naturally based mainly upon the species with which we are most familiar. Until forced to make authoritative comparative statements, it does not occur to one that the type of the genus under consideration may be quite different. An American student's conception of *Homalonotus* will probably be formed largely upon the species commonly known as *H. delphinocephalus* Green, from the Niagara, and *H. DeKayi* Green, from the Hamilton. The first time the type of the genus, *H. Knighti* Murchison, is seen he will be puzzled to place it. Similar examples could be multiplied indefinitely, and only show that the type must be taken as the ultimate unit of comparison.

Diagnoses and Discussions of Orders and Families.

Order A. HYPOPARIA, n. ord.

(ὕπό under, and πᾶρειά cheek piece.)

Free cheeks forming a continuous marginal ventral plate of the cephalon, and in some forms also extending over the dorsal side at the genal angles. Suture ventral, marginal, or submarginal. Compound paired eyes absent; simple eyes may occur on each fixed cheek, singly or in pairs.

Including the families Agnostidæ, Harpedidæ, and Trinucleidæ.

This order includes the groups C and D, or the *Ampycini* and *Agnostini* of Salter, and also the family Harpedidæ of that author, which he included in the *Asaphini*. The special recognition of characters, however, between Salter's groups and the order here proposed is different.

The presence of a part homologous with the free cheeks of other trilobites has generally been more or less overlooked in the families of this order. In *Trinucleus*, *Dionide*, and *Harpes*, the sutures have been correctly determined by Barande.³ Likewise, Angelin⁷ gave the right structure in *Ampyx*, but in *Agnostus*, this feature has escaped notice. The examination of extensive series of *Agnostus*, in the National Museum and in the Museum of Comparative Zoölogy,* has proved that under favorable conditions of preservation this genus shows a distinct plate, separated from the cranium by a suture, and it can be compared only with the free cheeks in other trilobites,

* In the former, through the courtesy of C. D. Walcott and C. Schuchert, and in the latter, of A. Agassiz and R. T. Jackson.

especially where they are continuous around the front of the cephalon, as in *Trinucleus* and *Ampyx*. The presence of a hypostoma in *Agnostus* was also determined. Even in the higher genera of this order, the suture is frequently unnoticed in descriptions, but it can be seen in all well-preserved specimens. In *Trinucleus*²⁹ and *Harpes*, it follows the edge of the cephalon, and separates the dorsal from the ventral plate of the pitted limb. Since eye spots occur on the fixed cheeks in the young *Trinucleus* and adult *Harpes*, it is probable that this character is a primitive one in this order, and has been lost in *Agnostus*, *Microdiscus*, *Ampyx*, and *Dionide*.

The ontogeny of *Sao*, *Ptychoparia*, *Triarthrus*, *Dalmanites*, etc., shows that the true eyes and free cheeks are first developed ventrally, appearing later at the margin, and then on the dorsal side of the cephalon. Therefore, the Agnostidæ, Trinucleidæ, and Harpedidæ have a very primitive head structure, characteristic of the early larval forms of higher families. Other secondary features show that this order, though the most primitive in many respects, is more specialized than either of the others, except in their highest genera. The characters referred to are the glabella and pygidium. Very few species show the primitive segmentation of the glabella, it being usually smooth and inflated, and resembling in its specialization such higher genera as *Proëtus*, *Asaphus*, and *Lichas*. The pygidium often fails to indicate its true number of segments. Some *Agnostus* and *Microdiscus* show no segments either on the axis or limb of the pygidium. *Trinucleus* and others may have a many annulated axis and fewer grooves on the pleural portions. The number of appendages corresponds to the axial divisions, as determined by the writer.⁴ The multiplication of segments in the pygidium and their consequent crowding makes them quite rudimentary.

Family I. AGNOSTIDÆ Dalman.

Small forms, having the cephalon and pygidium elongate, nearly equal, and similar in form and markings. Free cheeks ventral, continuous; suture marginal or ventral. Eyes wanting. Thorax composed of from two to four segments, with grooved pleura. Cambrian and Ordovician.

Including the genera *Agnostus* Brongniart, and *Microdiscus* Emmons.

The genera in this family are primitive in their form and structure, as shown by their ventral free cheeks, marginal or ventral suture, elongate cephalon, and large pygidium. Some

species have spines at the genal angles, corresponding to the interocular spines of *Holmia*, and young *Elliptocephala*, and not to the spiniform projections of the free cheeks. From their abbreviated thorax, and progressive loss of annulations on the glabella and axis of the pygidium, they must also be considered as degraded. *Microdiscus*, the earlier genus, has three or four free segments, and in some species (*M. speciosus* Ford) preserves the normal pentamerous glabella and annulated pygidial axis, while the later genus, *Agnostus*, has but two free segments, and has lost the annulations of both glabella and pygidium. Matthew²⁰ has described the protaspis stage of *Microdiscus*, which agrees with the similar stage of *Ptychoparia* and *Sao*.

Fully a dozen generic names have been proposed for forms of the general type of *Agnostus*, but none of them has ever come into current use. Nine were first published by Corda,¹⁸ but as Barrande³ subsequently showed that one was based on an *Orbicula*, another on a poor specimen of *Æglina*, and three others on a single species, this grouping soon fell into disuse. Moreover, Barrande was inclined to give no generic value to the form and lobation of the glabella, and therefore all the species were placed by him in the single genus *Agnostus*. At the present time, more weight is given to the characters of the glabella and pygidium, as indicating generic differences in dorsal and ventral structure, so that further study may show the desirability of restoring such of Corda's names as were founded upon natural groups of this family.

Family II. HARPIDIDÆ Barrande.

Cephalon large, margined by a broad expansion or limb; glabella short and prominent. Free cheeks ventral, continuous; suture marginal, following the outer edge of the limb. Paired simple eye spots, or ocelli, single or double, at the distal ends of well-marked eye lines on the fixed cheeks, extending outward from the glabella. Thorax of from twenty-five to twenty-nine segments, with long grooved pleura. Pygidium (in *Harpes*) very small, composed of but three or four segments.

Cambrian to Devonian.

Including *Harpes* Goldfuss, *Harpina* Novák, and *Harpides*? Beyrich.

The genus *Harpes* presents considerable variation in the lobes of the glabella. *H. unguia* Sternberg shows the full number of five lobes, but in some species, as *H. d'Orbignyianum*

Barrande, the structure is like *Cyphaspis*, with separate basal lobes. *Arraphus* Angelin was apparently based upon a specimen of *Harpes* denuded of the pitted border. *Harpides* Beyrich is imperfectly known but seems to belong here. The ocular ridges and tubercles on the fixed cheeks, the broad limb, the glabella, and the narrow weak thoracic segments are all in accord with *Harpes*, though in other features it has affinities with the Conocoryphidæ.

In many respects, *Harpes* is one of the most interesting genera of trilobites since it is so unlike other forms. The broad hippocrepian pitted limb of the cephalon has its counterpart in *Trinucleus* and *Dionide*, although not so well developed in these genera. The head is also comparatively longer and larger, both features being decidedly larval. It is the only family known in which functional visual spots, or ocelli, are situated on the fixed cheeks. The young *Trinucleus* has similar eye spots, or ocelli. The great number of free segments in the Harpedidæ is another primitive character, although the cephalon (in *Harpes*) still remains larger than the thorax and pygidium.

Family III. TRINUCLEIDÆ Barrande.

Cephalon larger than the thorax or pygidium; genal angles produced into spines. Free cheeks continuous, almost wholly ventral, carrying the genal spines; suture marginal or submarginal. Paired simple eyes or ocelli generally absent in adult forms; compound eyes wanting. Segments of thorax five or six in number, with grooved pleura. Pygidium triangular; margin entire; axis with a number of annulations; limb grooved.

Ordovician and Silurian.

Including the genera and subgenera *Trinucleus* Lhwyd, *Ampyx* Dalman, *Dionide* Barrande, *Endymionia* ? Billings, *Lonchodomus* Angelin, *Raphiophorus* Angelin, and *Salteria* ? W. Thompson.

The leading genera of this family form a tolerably homogeneous group, although each has sometimes been recognized as characterizing a separate family. *Trinucleus* and *Dionide* have a broad pitted border, but this hardly seems of sufficient importance to remove them far from *Ampyx*, since the three genera agree in nearly all important structural details, as the extent and character of the free cheeks, the glabella, the number of free segments, and the character of the pygidium. *Lonchodomus* and *Raphiophorus* of Angelin are commonly admitted as subgenera of *Ampyx*.

Both *Salteria* W. Thompson and *Endymionia* Billings have been described as subgenera of *Dionide* Barrande, though there is little positive evidence for this disposition of them. Until more perfect material representing these forms has been described, it will not be possible to decide satisfactorily upon their relationships or place in a classification. Therefore, they are left with doubt in the present family.

Order B. OPISTHOPARIA, n. ord.

(ὄπισθε behind, and πᾶρεια cheek piece.)

Free cheeks generally separate, always bearing the genal angles. Facial sutures extending forwards from the posterior part of the cephalon within the genal angles, and cutting the anterior margin separately, or rarely uniting in front of the glabella. Compound paired holochroal eyes on free cheeks, and well developed in all but the most primitive family.

Including the families Conocoryphidæ, Olenidæ, Asaphidæ, Proëtidæ, Bronteidæ, Lichadidæ, and Acidaspidæ.

This order is nearly equivalent to group B, or the *Asaphini* of Salter, which included also the families Calymenidæ and Harpedidæ, which belong elsewhere.

The families which are here placed under this order lend themselves quite readily to an arrangement based upon the characters successively appearing in the ontogeny of any of the higher forms. Thus *Sao*, *Ptychoparia*, and other genera of the Olenidæ have first a protaspis stage only comparable in the structure of the cephalon with the genera of the preceding order, the Hypoparia. Therefore this stage does not enter into consideration in an arrangement of the families of the Opisthoparia. In the later stages, however, there is a direct agreement of structure with the lower genera of this order. The nepionic *Sao*, with two thoracic segments (Plate III, fig. 2), has a head structure agreeing in essential features with that in *Atops* or *Conocoryphe* (Plate III, figs. 14, 15). A later nepionic stage, with eight thoracic segments (Plate III, fig. 3), agrees closely with adult *Ptychoparia* or *Olenus* (figs. 16, 17). These facts clearly indicate that the family Conocoryphidæ should be put at the base of this extensive order. Then, as *Ptychoparia* and *Olenus* are more primitive and simple genera than *Sao*, they, as typifying the family Olenidæ, should govern its position, which accordingly would be next after the Conocoryphidæ. In each case, a family is considered as represented by its typical and most characteristic forms. It would be impossible to

consider the advanced specialized genera of some families as representing their normal facies, for each one has undergone an independent evolution, and some characters have reached as great a degree of differentiation as will be found in much higher families.

It has been recognized that variations in the positions of the eyes, the relative size of the free and fixed cheeks, and the degree of specialization of the glabella have a definite order in the ontogeny of any trilobite, and also that these characters have a greater taxonomic value than many others. Applying these principles in arranging the families which come under the Opisthoparia, we have the sequence as indicated above, beginning with the Conocoryphidæ and followed by the Olenidæ, Asaphidæ, Proëtidæ, Bronteidæ, Lichadidæ, and Acidaspidæ, in regular progression. See Plate III, figs. 14–23.

Family IV. CONOCORYPHIDÆ Angelin.

Free cheeks very narrow, forming the lateral margins of the cephalon, and bearing the genal spines. Fixed cheeks large, usually traversed by an eye line extending from near the anterior end of the glabella. Facial sutures running from just within the genal angles, curving forward, and cutting the anterior lateral margins of the cephalon. Eyes rudimentary or absent. Thorax with from fourteen to seventeen segments. Pygidium small and of few segments. Cambrian.

Including the genera and subgenera *Conocoryphe* Corda (= *Conocephalites* Barrande), *Aneucanthus* Angelin, *Atops* Emmons, *Avalonia* Walcott, *Bailiella* Matthew (= *Salteria* Walcott and *Erinnys* Salter), *Bathynotus* Hall, *Carausia* Hicks, *Carmon* Barrande, *Otenocephalus* Corda, *Dictyocephalites* Bergeron, *Eryx* Angelin, *Harttia* Walcott, and *Toxotis* Wallerius.

The genera coming under this family present a number of very primitive characters such as are shown only in the larval stages of higher forms. The free cheeks are narrow and marginal, and can be compared with those in the nepionic stages of *Sao* and *Ptychoparia*. The eyes have not been detected, but the presence of an eye line suggests their possible existence. The variations of the glabella are very marked, and are as great as those which in higher forms attain some importance as family characteristics. In *Toxotis*, *Carausia*, and *Aneucanthus*, the glabella expands in front, joining and forming part of the anterior margin, as in the glabella of the larval stages of *Solen-*

opleura, *Liostracus*, *Ptychoparia*, and *Sao*. *Otenocephalus* and *Eryx* are slightly more advanced, as the glabella no longer marks the edge of the cephalon. In *Atops*,* *Avalonia*, *Bathynotus*, and *Carmon*, the glabella is cylindrical, distinctly defined, and limited within the margin, and in *Conocoryphe*, *Harttia*, and *Bailiella*, it narrows anteriorly, and only extends about two-thirds the length of the head. Generally in this family, the glabella displays its primitive pentamerous origin. In *Bailiella* and *Carausia*, two basal lobes are marked off from the fourth segment by oblique furrows, as in *Proetus* and *Cyphaspis*.

From a phylogenetic standpoint, the family Conocoryphidæ is at the base of this extensive order. As far as known, all the larval forms in the other families of the Opisthoparia agree in having the narrow marginal free cheeks, bearing the genal angles. The eye line is present in most of the adult Olenidæ, and in the early stages of all as far as known, so that the general average of the characters in the Conocoryphidæ represents the main larval features throughout the other families. They show, too, that although primitive in essential structure, differentiation through time has developed secondary features belonging to genera in higher families, as, for example, the basal glabellar lobes in *Bailiella*.

Family V. OLENIDÆ Salter.

Cephalon larger than the pygidium, usually wider than long; genal angles commonly produced into spines. Free cheeks separate. Facial sutures extending forward from the posterior margin of the cephalon along the eye lobes, and either cutting the anterior margin separately or meeting on the median line. Eyes crescentic, reniform, or semicircular, situated at the ends of eye lines in all but highest genera. Trunk long, composed of from eight (?) to twenty-six free segments; rarely capable of rolling up. Pygidium frequently small; margin entire or spinose.

Principally Cambrian, but extending into the Ordovician.

Including the genus *Olenus* Dalman as the type, and the following genera and subgenera, which should doubtless fall into several subfamily or even family groups: *Acerocare* Angelin, *Acrocephalites* Wallerius, *Agraulus* Corda, *Angelina* Salter, *Anomocare* Angelin, *Anopolenus* Salter, *Asaphe*

* *Atops* (type *A. trilineatus* Emmons) seems to be a valid genus, and differs from *Conocoryphe* (type *C. Sulzeri* Schlothheim) in its glabellar characters, greater number of thoracic segments, and much smaller pygidium with fewer segments.

lina Bergeron, *Bavarilla* Barrande, *Bergeronia* Matthew, *Boeckia* Brögger, *Ceratopyge* Corda, *Chariocephalus* Hall, *Corynæochus* Angelin, *Crepicephalus* Owen, *Ctenopyge* Linnarsson, *Cyclognathus* Linnarsson, *Dikelocephalus* Owen (*Centropleura* Angelin), *Dorypyge* Dames, *Ellipsocephalus* Zenker, *Elliptocephala* Emmons, *Euloma* Angelin, *Eurycare* Angelin, *Holmia* Matthew, *Hydrocephalus* Barrande (=young *Paradoxides*), *Leptoplastus* Angelin, *Liostracus* Angelin, *Loganellus* Devine, *Menocephalus* Owen, *Mesonacis* Walcott, *Micmacca* Matthew, *Neseuretus* Hicks, *Olenelloides* Peach, *Olenellus* Hall, *Olenoides* Meek, *Oryctocephalus* Walcott, *Palæopyge* Salter, *Parabolina* Salter, *Parabolinella* Brögger, *Paradoxides* Brongniart, *Peltura* Angelin, *Plutonides* Hicks, *Proceratopyge* Wallerius, *Protagraulus* Matthew, *Protolenus* Matthew, *Protopeltura* Brögger, *Protypus* Walcott, *Pterocephalia* Roemer, *Ptychaspis* Hall, *Ptychoparia* Corda, *Remopleurides* Portlock, *Sao* Barrande, *Schmidtia* Marcou, *Solenopleura* Angelin, *Sphærophthalmus* Angelin, *Telephus* Barrande, *Triarthrella* Hall, *Triarthrus* Green, and *Zacanthoides* Walcott.

A complete study of this extensive family of trilobites would contribute much in the way of generic synonymy, and bring out the characters necessary for family determination and subdivision. This important work must be left for future investigation. So many genera have been described from separate cranidia or even pygidia as to make it impossible to deal with all of them in a systematic manner. The zeal to make the most out of the earliest known faunas has led many investigators to describe and recognize imperfect and poorly preserved material, and to establish genera upon very tenuous characters. Therefore, without a most intimate knowledge of all the forms, any grouping of the majority of the Cambrian genera into families or the limitations of the genera themselves must, as in the present instance, be taken tentatively and as necessarily incomplete.

A number of genera have already been made the types of family divisions, as *Paradoxides*, *Olenellus*, *Remopleurides*, *Ellipsocephalus*, *Ptychoparia*, etc. Some of them may be shown ultimately to possess characters of sufficient weight to be entitled to family distinction. A preliminary grouping of the best known genera may be of some value here, and for the sake of convenience, these divisions may be defined as subfamilies. Four groups will be recognized, of which *Paradoxides*, *Oryctocephalus*, *Olenus*, and *Dikelocephalus* are taken as representative genera.

I. *Paradoxinae*. Including *Olenellus*, *Holmia*, *Mesonacis*, *Elliptocephala*, *Schmidtia*, *Olenelloides*, *Paradoxides*, *Zacanthoides*, and *Remopleurides*. Most of the genera are distinguished by their long narrow eyes, often extending more than half the length of the glabella, but more especially by the rudimentary character of the pygidium. In *Olenellus*, the pygidium is a long telson-like spine. In *Holmia*, *Mesonacis*, *Elliptocephala*, and *Schmidtia*, it is reduced to a small plate without distinct segmental divisions. In *Paradoxides*, *Zacanthoides*, and *Remopleurides*, the axis may show from one to five annulations, while the limb may carry two or three pairs of spines or may be entire. In *Olenellus* and *Holmia*, true facial sutures have been denied by some authors, but in their place false sutures are recognized. They are, however, evidently real sutures in a condition of symphysis, which often occurs in *Phacops*, *Proetus*, *Phillipsia*, etc. Otherwise, these genera would violate the first principle of trilobite structure, in not having the compound eyes on the free cheek pieces. *Olenelloides* is a very striking form, but its pygidium is unknown, and the head structure is obscure. The elongate cephalon is a decidedly larval feature, and the genal and interocular (?) spines strongly suggest its immature condition, and point to the possibility of its being the young of *Olenellus* or a related form.

There has been much discussion as to the synonymy and value of most of the names proposed as genera or subgenera in this group. *Paradoxides*, *Remopleurides*, and *Zacanthoides* are about the only ones that have escaped severe criticism in recent years. Taking the type of each of the others, it is found that *Elliptocephala* (1844) was based on the species *E. asaphoides* Emmons, *Olenellus* (1862) on *O. Thompsoni* Hall, *Mesonacis* (1885) on *M. vermontana* Hall sp., *Holmia* (1890) on *H. Kjerulfi* Linnarsson sp., *Schmidtia* (1890) on *S. Mickwitzi* Schmidt sp., and *Olenelloides* (1894) on *O. armatus* Peach. Some of these names are generally recognized as subgenera of *Olenellus* (*Mesonacis*, *Holmia*, *Olenelloides*), while others are considered as synonyms (*Elliptocephala*, *Schmidtia*). The early genera were described from very incomplete material, and therefore lacked sufficient diagnostic characters to clearly define them. At the present time, nearly or quite entire specimens representing the type species are known, and it is possible to compare all the essential features with some degree of accuracy. The main characters offering the greatest variation are (1) the number of thoracic segments and (2) their specialization into groups, (3) the relative development of the third free segment, (4) the number and position of the spine-bearing segments, (5) the form of the pygidium,

(6) the presence or absence of interocular spines, and (7) the form of the cephalon. A simple variation in any one of these would not necessarily imply more than a specific difference, but the genera here mentioned exhibit marked changes in all or nearly all of these characters, and in any family should receive recognition. *Olenellus*, *Mesonacis*, and *Elliptocephala* are more closely related than the other forms, and probably have only a subgeneric value under *Elliptocephala*. In the first form with fourteen thoracic segments, the third is greatly enlarged and the fifteenth is the spiniform, telson-like pygidium. In *Mesonacis* with twenty-six thoracic segments, the third is somewhat enlarged, and behind the narrow spine-bearing fifteenth segment there are eleven others without spines, followed by the small plate-like pygidium. In *Elliptocephala* with eighteen thoracic segments, the cephalon is broader, the third segment is not enlarged except in the young, and the fourteenth to eighteenth segments are narrower and spine-bearing.

II. *Oryctocephalinæ*. Including *Oryctocephalus*, *Ctenopyge*, *Olenoides*, and *Parabolina*, with large pygidia and all but the last one or two pleural elements continued into spines; also *Eurycare*, *Angelina*, *Peltura*, and *Protopeltura*, with smaller and shorter pygidia and denticulations of the margins corresponding to the pleural divisions.

III. *Oleninæ*. Including *Olenus*, *Agraulus*, *Liostracus*, *Acerocare*, *Ptychoparia*, *Solenopleura*, *Ptychaspis*, *Leptoplastus*, *Loganellus*, *Sphærophthalmus*, *Parabolinella*, *Boeckia*, *Proceratopyge*, *Ceratopyge*, *Protypus*, *Ellipsocephalus*, *Sao*, and *Triarthrus*. All these genera have small or medium-sized pygidia, with from two to eight annulations in the axis. Eyes medium to small, at the ends of distinct eye lines in all but the latest genera, which preserve this character only during the young stages. Thoracic segments from eleven to eighteen.

IV. *Dikelocephalinæ*. Including *Dikelocephalus*, *Asaphelina*, and *Crepicephalus*. Eight or nine thoracic segments. Pygidium wide, with the posterior lateral portion often produced into broad spine-like extensions. *Dikelocephalus* is in many ways related to *Ogygia* and *Asaphus*.

Family VI. ASAPHIDÆ Emmrich.

Cephalon and pygidium well developed; glabella often obscurely limited. Free cheeks usually separate. Facial sutures extending forward from the posterior edge of the cephalon within the genal angles, and cutting the lateral or anterior margins, occasionally uniting in front of the glabella.

Eyes smooth, well developed, sometimes of very large size, even occupying the entire surface of the free cheeks. Thorax generally composed of eight or ten segments, but varying from five to ten; capable of enrollment. Pygidium large, often with wide doublure.

Cambrian, Ordovician, and Silurian.

The long list of genera in this family may easily be divided into two sections, which are often recognized as of family rank.

I. ASAPHIDÆ. Including the genera and subgenera *Asaphus* Brongniart (= *Cryptonymus* Eichwald), *Asaphellus* Callaway, *Asaphiscus* Meek, *Barrandia* McCoy, *Basilicus* Salter, *Bathyurellus* Billings, *Bathyriscus* Meek, *Bathyrurus* Billings, *Bolbocephalus* Whitfield, *Brachyaspis* Salter, *Bronteopsis* W. Thompson, *Dolichometopus* Angelin, *Gerasaphes* Clarke, *Holasaphus* Matthew, *Homalopecten* Salter, *Isotelus* DeKay, *Megalaspides* Brögger, *Megalaspis* Angelin, *Niobe* Angelin, *Ogygia* Brongniart, *Ogygiopsis* Walcott, *Phillipsinella* Novák, *Platypeltis* Callaway, *Ptychopyge* Angelin, and *Stygina* Salter.

This is a tolerably homogeneous group, although some of the Cambrian forms have a sufficiently archaic expression to make them seem a little out of place with genera of so pronounced a family type as *Asaphus*, *Niobe*, *Ptychopyge*, *Megalaspis*, and *Isotelus*.

The elements of the glabella are generally quite obscure, and even its limits cannot be clearly made out in late genera, as *Stygina* and *Asaphus*. The segmental nature of the glabella is clearly shown in *Ogygia*, *Ogygiopsis*, *Homalopecten*, *Asaphellus*, *Bronteopsis*, and *Bathyriscus*.

The elements of the pygidium are obscurely marked in *Brachyaspis* and *Isotelus*. *Phillipsinella* is a very small form, and probably the young of an *Asaphus*. *Barrandia*, *Homalopecten*, and *Stygina* serve as transition genera to the Illænidæ.

II. ILLÆNIDÆ. Including the genera and subgenera *Illænus* Dalman, *Æglina* Barrande (= *Cyclopyge* Corda), *Bumas-tus* Murchison, *Dysplanus* Burmeister, *Ectillænus* Salter, *Holocephalina* Salter, *Hydrolenus* Salter, *Illænopsis* Salter, *Illænurus* Hall, *Nileus* Dalman, *Octillænus* Salter, *Panderia* Volborth, *Psilocephalus* Salter, *Symphysurus* Goldfuss, and *Thaleops* Conrad.

The Illænidæ form a much more compact group than the preceding, characterized by having an epistomal plate and by

the very tumid form of the large cephalon and the obscure or obsolete boundaries of the glabella and occipital lobe. The pygidium often closely resembles the cephalon in size and form, and the axis is frequently scarcely defined.

Considerable variation is shown in the size, position, and direction of the visual surfaces. There is also a ratio between the size of the fixed cheeks and the eyes. In proportion as the fixed cheeks are large, the eyes are small, and as the area of the fixed cheeks diminishes from a widening of the axis of the animal, the eyes become larger. Thus, in *Holocephalina*, with extremely large fixed cheeks and narrow axis, the eyes are quite small. In *Illænopsis*, *Dysplanus*, *Panderia*, and *Octillænus*, they are progressively larger, and in *Illænus*, *Bumastus*, and *Nileus*, where the axis is wide and the fixed cheeks reduced, the eyes are relatively large. This variation reaches its limit in the species of *Æglina*, where the axis is very wide and the fixed cheeks are reduced to almost nothing, so that the glabella and eyes make up the entire dorsal surface of the cephalon. In *Æglina princeps* Barrande, the eyes extend about half the length of the cephalon. The eyes of *Æ. rediviva* Barr. bound the whole length of the sides of the head, and in *Æ. armata* Barr., the coalesced free cheek pieces are almost wholly converted into a visual area, so that there is a continuous eye around the sides and front of the head.

Variations in the position of the eyes are to be noted in nearly all the genera. In *Ectillænus* and *Psilocephalus*, they are in front of the middle of the length of the cephalon, and in *Dysplanus*, *Illænopsis*, and *Holocephalina*, they are near the posterior angles of the cranidium. *Panderia* has the eyes directed obliquely backward, and in *Thaleops*, they are carried on conical extensions pointing outwards.

Family VII. PROËTIDÆ Barrande.

Cephalon about one-third of the whole animal; genal angles generally produced into spines; glabella tumid, with two lateral basal lobes defined by oblique furrows in front of the neck segment. Free cheeks large, separate. Sutures extending from the posterior margin inward to the eyes, and then forward, cutting the anterior margins separately. Eyes prominent, often large. Thorax of from eight to twenty-two free segments, with grooved pleura. Pygidium usually of many segments; pleural and axial portions strongly grooved; margin entire or dentate. Ordovician to Permian.

Including the genera and subgenera *Proëtus* Steininger,

Arethusina Barrande, *Brachymetopus* McCoy, *Celmus* Angelin, *Cordania* Clarke, *Crotalurus* Volborth, *Cyphasps* Burmeister, *Dechenella* Kayser, *Griffithides* Portlock, *Phaëtonella* Novák, *Phillipsia* Portlock, *Prionopeltis* Corda, *Pseudophillipsia* Gemmellaro, *Schmidtella* Tschernyschew, *Tropidocoryphe* Novák, and *Xiphogomium* Corda.

The genera of this family readily fall into a series expressing more or less closely the development and specialization of various characters. *Arethusina* is the only genus retaining the archaic eye lines, and both on this account and for the comparatively forward position of the eyes (itself a nepionic character), together with the large number of thoracic segments, it stands near the base of the series.

The eyes gradually approach the axis, and move backward through the genera *Tropidocoryphe*, *Cyphasps*, *Proëtus*, *Prionopeltis*, *Phillipsia*, and *Griffithides*. Concurrent with this variation, there is a reduction of the fixed cheeks and extension of the glabella. In *Arethusina*, *Tropidocoryphe*, *Cordania*, and *Cyphasps*, the fixed cheeks are about the size of the free cheeks, and occupy a large portion of the cranium. They are more reduced in *Proëtus* and *Prionopeltis*, and in *Phillipsia* and *Griffithides*, they form only a narrow border to the glabella. The lobation of the glabella varies greatly, and few species retain evidences of its original segmental nature. Some *Proëtus* and *Dechenella* show this feature, but in many *Phillipsia* and *Griffithides* the elements cannot be made out. In *Proëtus*, there is often a small accessory lobe developed at the ends of the neck ring, which is only of interest as being homologous with similar lobes in many of the Lichadidæ and Acidaspidæ, where they often become very conspicuous. In all the Proëtidæ, the oblique lobes of the fourth annulus of the glabella are also important in this connection, as here again is marked the inception of side axial lobes, which become prominent features in higher genera, indicating greater specialization of the organs and appendages of the head.

FAMILY VIII. BRONTEIDÆ Barrande.

Dorsal shield broadly elliptical. Cephalon less than one-third the entire length; glabella rapidly expanding in front, with faint indications of lobes. Free cheeks larger than the fixed cheeks. Facial sutures extending from the posterior margin just behind the eyes abruptly inward around the palpebral

lobes, and then diverging and cutting the antero-lateral margins separately. Eyes crescentic. Thorax of ten segments, with ridged pleura. Pygidium longer than cephalon or thorax; axis very short, with radiating furrows extending from it across the broad limb toward the margin; doublure very wide; margin generally entire. Ordovician to Devonian.

Including the single genus *Bronteus* Goldfuss (= *Goldius* de Koninck).

Many of the species of *Bronteus* (as *B. angusticeps* Barr., *B. palifer* Bey.) show a breaking up of the glabella into symmetrically disposed separate lobes, as in *Conolichas* and *Acidaspis*. The frontal lobe is transverse and much larger than the others. Back of it may be simple grooves marking the elements (*B. campanifer* Bey.), or there may be one or two circular or elliptical swellings on each side of the axis (*B. angusticeps* Barr.), or in addition, the axial portion may consist of several lobes. The reduction of the axis of the pygidium and the expansion of the limb meet with their greatest expression in this genus. *Lichas* shows the decline of these characters, the pygidial limb becoming more or less deeply lobed, and finally the lobes are represented by spines (*Arges*, *Terataspis*). Further progression of these changes is shown in *Acidaspis*.

Family IX. LICHADIDÆ Barrande.

Dorsal shield generally large and flat, with granulated test. Cephalon small, not more than one-fourth the entire length; genal angles spiniform. Free cheeks separate; sutures extending from the posterior margin obliquely inward to the eyes, and then almost directly forward, cutting the margin separately. Glabella broad, with a large, often tumid, central lobe and from one to three side lobes. Eyes not large. Thorax with nine or ten segments and grooved and falcate pleura. Pygidium large, flat, commonly with toothed or notched margin corresponding to the pleural grooves; doublure very broad.

Ordovician to Devonian.

Including the genera and subgenera *Lichas* Dalman, *Arctinurus* Castelnau, *Arges* Goldfuss, *Ceratolichas* Hall and Clarke, *Conolichas* Dames, *Dicranognmus* Corda, *Homolichas* Schmidt, *Hoplolichas* Dames, *Leiolichas* Schmidt, *Metopias* Eichwald, *Oncholichas* Schmidt, *Platymetopus* Angelin, *Terataspis* Hall, *Trochurus* Beyrich, and *Uralichas* Delgado.

Most of the forms of this family are above the average size of trilobites, and several species are among the largest of the class. They are all thin-shelled, and were loosely articulated, so that entire specimens are extremely rare.

A great diversity is shown in the form and lobation of the glabella. In *Lichas* (sens. str.), *Platymetopus*, and *Leiolichas*, the anterior lobe dominates and is continuous with the axis. In *Hoploichas* and *Homolichas*, the lateral lobes are strongly defined, and each is nearly equal in size to the central lobe. *Dicranognmus*, *Oncholichas*, *Conolichas*, *Metopias*, *Arctinurus*, and *Arges* show the lateral lobes divided transversely into two or three smaller ones. Lastly in *Ceratolichas*, and more especially in *Terataspis*, the central lobe becomes a prominent ovoid or globular extension. These variations evidently indicate differences in the relative development of the appendages and organs of the head, and therefore are of considerable morphological importance.

The pygidium is composed of few distinct segments. The annulated portion of the axis is generally short, and the dentations on the border of the limb, corresponding to the pleural grooves, range from two to four on each side. *Leiolichas* is the only form which has an entire pygidial margin.

Family X. ACIDASPIDÆ Barrande.

Dorsal shield spinose. Cephalon transversely semi-elliptical, quadrate, or trapezoidal; genal angles spiniform. Glabella with one large median axial lobe and two or three lateral lobes. Free cheeks large, separate. Sutures extending from within the genal angles abruptly inward to the eyes, and then forward, cutting the anterior margin each side of the glabella. Eyes small, often prominent. Thorax of eight to ten segments, with ridged pleura extended into hollow spines. Pygidium usually small, with spinous margin. Ordovician to Devonian.

Including the genera and subgenera *Acidaspis* Murchison, *Ancyropyge* Clarke, *Ceratocephala* Warder, *Dicranurus* Conrad, *Odontopleura* Emmrich, and *Selenopeltis* Corda.

In this family and the Lichadidæ is shown the highest expression of differentiation and specialization of the Opisthoparia. The primitive pentamerous lobation of the axis of the cranium is entirely obscured, and is only clearly seen in the protaspis and early nepionic stages. These two families are very closely related, the chief differences being noticed in the size and character of the pygidium, and the ribbed or grooved

pleura. The Lichades are generally much larger and flatter, but the smaller and highly spinose forms of *Arges*, *Ceratolichas*, and *Hoplolichas* approach quite near some of the Acidaspidae.

It has been customary of late years to regard all the species of this family as belonging to the single genus *Acidaspis*, and to consider the various subdivisions bearing separate names as of the value of subgenera. Clarke¹⁴ has shown that, on the basis of priority, *Ceratocephala* is the first distinctive name ever applied to the group, and is therefore entitled to full generic recognition. He further recognizes *Odontopleura*, *Acidaspis*, *Dicranurus*, *Selenopeltis*, and *Ancyropyge*, in the subordinate position of subgenera under *Ceratocephala*.

Order C. PROPARIA, n. ord.

(*πρό* before, and *πᾶρεια* cheek piece.)

Free cheeks not bearing the genal angles. Facial sutures extending from the lateral margins of the cephalon in front of the genal angles, inward and forward, cutting the anterior margin separately or uniting in front of the glabella. Compound paired eyes scarcely developed or sometimes absent in the most primitive family, well-developed and schizochroal in last family.

Including the families Ecerinuridae, Calymenidae, Cheiruridae, and Phacopidae.

Salter's first division, *Phacopini*, included the two families Phacopidae and Cheiruridae. The Calymenidae were placed in his second division, the *Asaphini*.

This is the only order of trilobites which apparently begins within the known Paleozoic, and unlike the other orders, it had no pre-Cambrian existence. The earliest forms of the Proparia came at the close of the Cambrian, in the lower Ordovician. Its greatest generic differentiation was attained early. There is a rapid decline in the Silurian and Devonian, and only one or two genera extend to the beginning of the Carboniferous.

In the Opisthoparia, it was demonstrated that the Conocoryphidae formed the natural base or most primitive family in the order, and was distinguished by the narrow marginal free cheeks and the absence of well-developed eyes. It is of much interest and importance to be able to recognize, in the Proparia, a similar primitive family having characters in common with the former, but still clearly belonging to the higher order. *Placoparia*, *Areia*, and *Dindymene*, of the Ecerinuridae, constitute a group of apparently blind trilobites, with narrow mar-

ginal free cheeks, presenting in general the appearance of *Atops*, *Conocoryphe*, *Otenocephalus*, etc., of the Conocoryphidæ. The somewhat higher genera *Cybele* and *Encrinurus* have intermediate or transitional characters, leading to the other families. The Cheiruridæ show a greater amount of differentiation and progressive and regressive evolution than any other in this order. *Crotalocephalus* and *Sphærexochus* seem to express the highest development, and *Deirphon* and *Onycopyge* show the effects of over specialization, resulting in degeneration. The Calymenidæ, in their small eyes and narrow free cheeks, have decided affinities with the lower genera. The same may be said of *Trimeriocephalus* of the Phacopidæ, though the other genera of this family possess large eyes, situated well back and close to the glabella. For these and other reasons, the family is placed at the end of the order, as expressing its highest development.

Family XI. ENCRINURIDÆ Linnarsson.

Cephalon narrow, transverse. Fixed cheeks very large. Free cheeks long, narrow, separate, sometimes with a free plate between the anterior extremities. Sutures extending from in front of the genal angles obliquely forward, and cutting the anterior margin in front of the glabella. Eyes very small or absent. Thorax of from nine to twelve segments, with ridged plenra. Pygidium generally composed of many segments; limb with strong ribs usually less in number than the annulations of the axis. Ordovician and Silurian.

Including the genera *Encrinurus* Emmrich (*Cromus* Barrande), *Areia* Barrande, *Cybele* Lovén, *Dindymene* Corda, *Placoparia* Corda, and *Prosopiscus* Salter.

The Conocoryphidæ were shown to be the radical of the order Opisthoparia, and for similar reasons, the Encrinuridæ may now be taken as the primitive family of the Proparia. The cephalæ of *Areia* and *Placoparia* have many resemblances to *Conocoryphe*, but the fixed cheeks bear the genal angles and spines, while in the latter genus they are on the free cheeks. In both families, the free cheeks are narrow and marginal, and the eyes are absent or rudimentary. Both these characters are decidedly larval. Other primitive and larval features belonging to the Encrinuridæ are the eye lines in *Cybele* and *Encrinurus*, the undefined and expanded termination of the glabella in *Dindymene* and *Encrinurus*, and the pentamerous head axis in all but *Dindymene*, in which the four anterior lobes or

annulations are obsolete. In *Encrinurus*, the eye line in meeting and joining the anterior lobe of the glabella sometimes gives the appearance of an extra lobe, as in *Ogygia* and *Paradoxides*.

Family XII. CALYMENIDÆ Brongniart.

Cephalon somewhat wider than long. Fixed cheeks large; genal angles rounded or produced into spines. Glabella narrowing anteriorly. Free cheeks long, separate, usually with a free plate, the epistoma, between the anterior extremities. Sutures extending from just in front of the genal angles, converging anteriorly, and cutting the margins separately. Eyes small; visual surface seldom preserved. Thorax of thirteen segments, with grooved pleura. Pygidium of from six to fourteen segments; axis tapering. Ordovician to Devonian. .

Including the genera and subgenera *Calymene* Brongniart, *Brongniartia* Salter, *Burmeisteria* Salter, *Calymenella* Bergeron, *Calymenopsis* Munnier-Chalmas and Bergeron, *Dipleura* Green, *Homalonotus* Koenig, *Koenigia* (= *Homalonotus*) Salter, *Pharostoma* Corda, *Plæsiacomia* Corda, *Ptychometopus* Schmidt, and *Trimerus* Green.

The genera of this family naturally cluster around the two leading ones, *Calymene* and *Homalonotus*. Closely related to the first are *Ptychometopus*, *Pharostoma*, *Calymenopsis*, and *Calymenella*, all agreeing in having the glabella well defined and marked by furrows or indentations at the sides, corresponding to its segmental nature.

The second group, including *Brongniartia*, *Trimerus*, *Homalonotus* (sens. str.), *Plæsiacomia*, *Dipleura*, and *Burmeisteria*, agree in having a low, not sharply defined, quadrate glabella, without distinct furrows or lobes. In general, the axis of the thorax and pygidium is much wider than in the first group, and the pygidium is more elongate and often pointed.

Family XIII. CHEIRURIDÆ Salter.

Glabella well defined. Free cheeks small, sometimes much reduced. Sutures extending from in front of the genal angles inward to the eyes, and then obliquely forward, cutting the anterior margin in front and each side of the glabella. Eyes usually small. Thorax composed of from nine to eighteen segments, generally eleven; pleura often extended into hollow spines. Pygidium small, with from three to five segments; pleural elements commonly produced into spines.

Principally Ordovician and Silurian, but extending into the Devonian.

Including the genera and subgenera *Cheirurus* Beyrich, *Actinopeltis* Corda, *Amphion* Pander, *Anacheirurus* Reed, *Ceraurus* Green, *Crotalocephalus* Salter, *Cyrtometopus* Angelin, *Deiphon* Barrande, *Diaphanometopus* Schmidt, *Eccoptocheile* Corda, *Hemisphærocoryphe* Reed, *Nieszkowskia* Schmidt, *Onycopyge* Woodward, *Pseudosphærexochus* Schmidt, *Sphærexochus* Beyrich, *Sphærocoryphe* Angelin, *Staurocephalus* Barrande, and *Youngia* Lindström.

As in other families, the most primitive genera are those in which the regular pentamerous lobation of the glabella is retained, the eyes are well forward, the free cheeks narrow, and the fixed cheeks ample. *Diaphanometopus*, *Anacheirurus*, *Eccoptocheile*, and *Cyrtometopus* agree in these respects, and therefore belong at the beginning of a phylogenetic list. *Ceraurus* and *Nieszkowskia* appear to branch off here, being characterized by the narrow transverse form of the cephalon and the great development of the two anterior pygidial pleura into hollow spines directed outward and backward. These features are simulated in *Deiphon*, in which, however, the prominent glabella is without distinct lobes, and the large pleural extensions of the pygidium do not belong to the anterior segment. Its natural place is at the end of the series. F. Cowper Reed²¹ has shown, in his memoir on the evolution of *Cheirurus* and its subgenera, not including the other genera of the family, that the direct line from *Cyrtometopus* passes through *Cheirurus* to *Crotalocephalus*. The genera *Pseudosphærexochus* and *Amphion* also have relations with these genera and should be placed here. There is next a group of forms, with prominent globular glabellæ, leading from *Cheirurus* to *Sphærocoryphe*, and including *Actinopeltis*, *Youngia*, and *Hemisphærocoryphe*. *Staurocephalus* should immediately follow these. *Sphærexochus* seems to be related to *Cheirurus* and *Actinopeltis*. Like them, it has two side lobes at the base of the glabella, and the anterior furrows are obsolescent, as in *Actinopeltis* and *Youngia*. Lastly come *Onycopyge* and *Deiphon*, with their globular glabellæ without furrows, the spiniform fixed cheeks, and thoracic and pygidial pleura, and the free cheeks reduced to almost nothing, forming a small part of the doublure of the cephalon. The former genus has four spiniform pygidial pleura, two on each side, but in the latter, two are reduced and the remaining pair is greatly enlarged.

Family XIV. PHACOPIDÆ Salter.

Glabella tumid, widest in front. Free cheeks continuous, united anteriorly. Suture extending from in front of the genal angles inward to the eyes, and then forward around the glabella. Eyes generally large, and always with distinct facets, schizochroal. Thorax with eleven segments, with grooved pleura. Pygidium usually large and of many segments; limb ribbed; margin entire or dentate. Ordovician to Devonian.

Including the genera and subgenera *Phacops* Emmrich, *Acaste* Goldfuss, *Chasmops* McCoy, *Coronura* Hall, *Corycephalus* Hall and Clarke, *Cryphaeus* Green, *Dalmanites* Emmrich (*Hausmannia* Hall and Clarke), *Homalops* Remele and Dames, *Monorachos* Schmidt, *Odontocephalus* Conrad, *Pterygometopus* Schmidt, *Symphoria* Clarke, and *Trimerocephalus* McCoy.

The last family of trilobites comprises forms which are commonly believed to be the most highly organized of the class, and certain it is that a high degree of organization is manifested. Some of the characters may be considered as progressive, while others are larval or possessed chiefly by the most primitive families, and are therefore to be looked upon as regressive. Schizochroal eyes occur in no other family, and this feature is apparently indeterminate. The complete union of the free cheeks, carrying the doublure of the sides and front of the cephalon, can be best homologized with similar structures in some of the lowest genera, and is a retention of the complete ocular segment. The glabella, though considerably enlarged anteriorly, does not attain the degree of specialization shown in *Lichas* and *Acidaspis*. Only *Chasmops* and related forms (*Monorachos*, *Homalops*, *Symphoria*, and *Coronura*) have separate or accessory lobes. The margin of the cephalon shows even greater diversity than in any other family. It may be plain (*Phacops*, *Cryphaeus*), notched (*Corycephalus*), denticulated (*Odontocephalus*), or extended in front as a spinose, spatulate, or dentate process (*Dalmanites nasutus* Conrad, *D. tridens* Hall, etc.). The pygidium has a range almost as great, though in this respect it is equalled in the Lichadidæ, Acidaspidæ, and some of the Olenidæ. In America, the section typified by *Dalmanites* culminated during the lower Devonian. Not only are the largest forms found here (*Coronura diurus* Green, *C. myrmecophorus* Green, *D. tridens* Hall, etc.), but also the most ornate and specialized, as *Corycephalus*, *Odontocephalus*, and *Coronura*.

Yale Museum, New Haven, Conn., December 28th, 1896.

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EXPLANATION OF PLATE III.

Figures are approximately of the same size to facilitate comparison. The dorsal areas of the free cheeks are shaded.

Ontogeny of Sao hirsuta Barrande.

- FIGURE 1.—Protaspis stage.
 FIGURE 2.—Cephalon; nepionic stage of individual having two free thoracic segments.
 FIGURE 3.—Cephalon; later nepionic stage of individual having eight free thoracic segments.
 FIGURE 4.—Cephalon of adult. Figures 1–4, after Barrande.

Ontogeny of Dalmanites socialis Barrande.

- FIGURE 5.—Protaspis stage.
 FIGURE 6.—Cephalon; nepionic stage of individual having three free thoracic segments.
 FIGURE 7.—Cephalon; nepionic stage of individual having seven free thoracic segments.
 FIGURE 8.—Cephalon of adult. Figures 5–8, after Barrande.

HYPOPARIA.

FIGURE 9.—Cephalon of <i>Agnostus</i> .	} Agnostidæ.
FIGURE 10.—Cephalon of <i>Microdiscus</i> .	
FIGURE 11.—Cephalon of <i>Harpes</i> .	} Harpedidæ.
FIGURE 12.—Cephalon of <i>Trinucleus</i> .	
FIGURE 13.—Cephalon of <i>Ampyx</i> .	} Trinucleidæ.

OPISTHOPARIA.

FIGURE 14.—Cephalon of <i>Atops</i> .	} Conocoryphidæ.
FIGURE 15.—Cephalon of <i>Conocoryphe</i> .	
FIGURE 16.—Cephalon of <i>Ptychoparia</i> .	} Olenidæ.
FIGURE 17.—Cephalon of <i>Olenus</i> .	
FIGURE 18.—Cephalon of <i>Asaphus</i> .	} Asaphidæ.
FIGURE 19.—Cephalon of <i>Ilænus</i> .	
FIGURE 20.—Cephalon of <i>Proëtus</i> .	} Proëtidæ.
FIGURE 21.—Cephalon of <i>Bronteus</i> .	
FIGURE 22.—Cephalon of <i>Lichas</i> .	} Lichadidæ.
FIGURE 23.—Cephalon of <i>Acidaspis</i> .	
	} Acidaspidæ.

PROPARIA.

FIGURE 24.—Cephalon of <i>Placoparia</i> .	} Encrinuridæ.
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ERRATA.

- Page 92, line 19, for *Zecanthoides* read *Zacanthoides*.
 Page 95, line 24, for enervate read innervate.
 Page 95, line 25, for enervated read innervated.
 Page 96, lines 31 and 34, for enervating read innervating.
 Page 103, line 18, for *Olenellus* read *Elliplocephala*.