CAMBRIAN FAUNAS OF CHINA.

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INTRODUCTION.

The presence of Cambrian fossils in China was first announced by Baron Richthofen in 1883.[a]

The material gathered by him was studied by Dr. E. Kayser, to whom the brachiopods were intrusted, and by Doctor Dames, who described the trilobites.

Doctor Kayser[b] described and named the following brachiopods:

Orthis linnarssoni
Lingulella sp.
L. sp.

Of the above we have identified from the collections of the Carnegie Institution of Washington Expedition to China *Orthis* [*Plectorthis*] *linnarssoni*.

Doctor Dames[c] described and named the following trilobites:

Agnostus chinensis.
Dorypyge richthofeni.
Anomocare latilimbatum.
Anomocare majus.
Anomocare minus.
Anomocare nanum.
Anomocare planum.
Anomocare subcostatum.
Conocephalites frequens.
Conocephalites quadriceps.
Conocephalites subquadratus.
Conocephalites typus.
Liostracus megalurus.
Liostracus talingensis.
? *Liostracus.*
? *Liostracus.*
2 Pygidia, genus and species undetermined.

Of the above we have identified from the collections of the Carnegie Institution of Washington Expedition to China:

Agnostus chinensis.
Dorypyge richthofeni.
Conocephalites [*Ptychoparia*] *frequens.*
Anomocare latilimbatum.
Anomocare minus.
Ptychoparia (*Liostracus*) *megalurus.*

[a] China, Richthofen, IV. [b] Idem, pp. 34–36. [c] Idem, pp. 3–33.

Doctor Dames compared the Cambrian trilobites with those of Europe, America, and India, and concluded that the trilobitic fauna of Sai-ma-ki and Taling were about the age of the Scandinavian Andrarum limestone and the Potsdam group of North America. He did not find any Chinese species that could be identified with those of Scandinavia and America; but the general appearance of the fauna as a whole was so similar that he said that their equal age may be considered proven.

He further states that the age of the rocks containing *Dorypyge richthofeni* from Wu-lo-pu is probably the same as that of the Quebec group, basing this upon comparisons with species from Utah, which he referred to the genus *Dorypyge*.[a]

The collections made by the Carnegie Institution of Washington Expedition prove that *Dorypyge richthofeni* occurs in the central portion of the Chang Hsia formation and is of Middle Cambrian age. Baron Richthofen's means of comparison were with the fauna referred to the Quebec group, which was at that time supposed to be of Lower Silurian (Ordovician) age.

In 1899 M. Bergeron[b] described the following Cambrian fossils from some shaly limestones collected in the province of Shangtung, China:

Agnostus douvillei.
Olenoides leblanci.
Drepanura premesnili.
Arthricocephalus chauveani.
Dicellocephalus? sinensis.
Calymmene? sinensis.

Of the above we have identified the following from the Ku San shale of the section made by Mr. Blackwelder:

Olenoides liblanci.
Drepanura premesnili.
Calymmene? [*Damesella*] *sinensis.*

From the Cambrian formations of Siberia, Dr. F. Schmidt[c] described the following fossils:

Agnostus czekanowskii.
Anomocare pavlowskii.
Liostracus maydeli.

This fauna was subsequently reviewed by Edward von Toll,[d] who added the following:

Conferrites primordialis Born.
Archæocyathus acutus Born.
Archæocyathus adunctus Born.
Archæocyathus patulus Born.
Archæocyathus proskurjakowi von Toll.
Archæocyathus sibiricus von Toll.
Archæocyathus ijizkii von Toll.
Coscinocyathus corbicula Born.
Coscinocyathus dianthus Born.
Coscinocyathus calathus Born.
Coscinocyathus campanula Born.
Coscinocyathus vesica Born.
Coscinocyathus elongatus Born.
Coscinocyathus irregularis von Toll.

[a] China, Richthofen, IV, pp. 31–33.
[b] Bull. de la Société Géol. de France, 3 ser., XXVII, p. 499.
[c] Bull. de l'Acad. Imp. des Sciences de St.-Pétersb., 1886, XII, p. 407.
[d] Mém. de l'Acad. Imp. des Sciences de St.-Pétersb., 8th ser., VIII, No. 10.

Coscinocyathus cf. cancellatus Born.
Spirocyathus, species undetermined.
Rhabdocyathus sibiricus von Toll.
Protopharetra, species undetermined.
Helminthoidichnites sp.
Kutorgina cingulata Bill.
? Obolella chromatica Bill.
Hyolithes, species undetermined.
Microdiscus lenaicus von Toll.
Microdiscus kochi von Toll.
Microdiscus, species undetermined.
Agnostus schmidti von Toll.
? Olenellus, species undetermined.
Doryppyge slatskowskii Schmidt.
Ptychoparia czekanowski von Toll.
Ptychoparia meglitzkyi von Toll.
? Solenopleura sibirica Schmidt.
Bathyuriscus howelli Walcott.

In the autumn of 1903 the Carnegie Institution of Washington sent an expedition to China under the direction of Mr. Bailey Willis, with Mr. Eliot Blackwelder as assistant in stratigraphic geology. One of the objects of the expedition was to obtain data of the Cambrian formations and contained faunas for the purpose of comparison, and correlation, if practicable, with the North American sections and faunas. Mr. Willis delegated to Mr. Blackwelder the study of the sections and very largely the collecting of the fossils. It was understood that the collections of Cambrian fossils should be studied by Mr. Walcott and the stratigraphic sections elaborated by Mr. Blackwelder.

A considerable quantity of material was collected and received in Washington in the fall of 1904. The preparation of the specimens for labeling was given to Mr. Henry Dickhaut, with instructions to work them up carefully and secure every species possible from the mass of fragments of trilobites, brachiopods, etc., of which nearly all the specimens of rock are composed. The material when thus prepared was labeled with locality and formation numbers and taken in hand by Miss Elvira Wood, who separated the species and selected and indicated specimens for illustration. I first studied the brachiopods in connection with my systematic study of the Cambrian brachiopoda, and published descriptions of 23 species in 1905.[a] Mr. Willis and Mr. Blackwelder informed me that they would like, in July, 1905, a list of all the species in the collections in order to use them in the correlation of the various sections and the discussion of the stratigraphic geology. To meet this request, I made a preliminary study of the fauna, and now publish it in advance of the illustrated report, which will not be ready to go to the printer before the spring of 1906. Many drawings have been prepared, but it will require several months to complete them.

In this preliminary study a number of free cheeks and pygidia of trilobites have been passed over, as the time available before I go to the field is not sufficient for the extended examinations and comparisons needed for a final paper.

The large fauna discovered in the reconnaissance made by Messrs. Willis and Blackwelder is an indication of the richness of the Cambrian faunas of eastern Asia, and of the great results that may be

[a] Proc. U. S. Nat. Mus., XXVIII, 1905, pp. 227–337.

expected when systematic, thorough exploration and collecting is undertaken. The following is a synopsis of the fauna as now known:

Name.	Genera.	Species.
Protozoa	1	1
Porifera	1	1
Brachiopoda	13	29
Gastropoda	4	8
Pteropoda	2	8
Cephalopoda	1	1
Trilobita	25	118
Ostracoda	1	6
Total	48	172

ASSOCIATION OF GENERA AND SPECIES.

In order that the student may be saved the labor of making lists of the species from the various localities, the following lists are inserted. The species given in each list do not all occur in the same layer of rock, but they are from the same band of layers. The number of layers and their thickness will be given in Mr. Blackwelder's report on the detailed sections. The stratigraphic range is limited so as to avoid the commingling of faunas from distinct faunal zones.

The line between the Middle and Upper Cambrian faunas is placed at the top of the Ku San shale. The fauna of the Ku San shale includes species of *Damesella*, *Dorypyge*, and genera that are typical of the Middle Cambrian fauna, while the fauna of the Chao Mi Tien limestone, above the Ku San shale, is more nearly related to that of the Upper Cambrian of North America and northwestern Europe.

The line of the Lower Cambrian is placed at the top of the Man To formation, as the predominant trilobite, *Redlichia*, is more closely related to *Olenellus* than to the trilobites of the Middle Cambrian fauna.

Upper Cambrian.....Chao Mi Tien formation....

Brachiopoda:
- *Craniella ??* sp.
- *Obolus matinalis*, *O.* sp.
- *O.* (*Lingulella*) *damesi*.
- *Syntrophia orientalis*, *S. orthia*.
- *Plectorthis doris*, *P. kayseri*, *P. linnarssoni*, *P. pagoda*.
- *Billingsella pumpellyi*.

Gastropoda:
- *Scenella*, species undetermined.
- *Straparollina circe*.
- *Platyceras clytia*, *P. pagoda*.
- *Stenotheca*, species undetermined.

Pteropoda:
- *Hyolithes daphnis*.
- *Orthotheca cyrene*, *O.*, species undetermined

Cephalopoda:
- *Cyrtoceras cambria*.

Trilobita:
- *Agnostus chinensis*.
- *Anomocare bergioni*, *A. bianos*.
- *Anomocarella baueis*, *A. carme*.
- *Menocephalus* (*?*) *depressus*.

Upper Cambrian.....Chao Mi Tien formation....

Trilobita—Continued.
Pagodia bia, P. dolon, P. lotos, P. macedo.
Pterocephalus busiris.
Ptychaspis acamus, P. cacus, P. cadmus, P. calchas, P. callisto, P. calyce, P. campe, P. ecto, P. sp.
Ptychoparia (?) batia, P. dryope.
P. (Proampyx) burea.
Solenopleura bolus, S. heroe.
Dikelocephalus (?) bambo, D. (?) brizo.
Illaenurus canens, I. ceres, I. dictys.

Middle Cambrian....Ku San formation.....

Brachiopoda:
Obolus (Westonia) blackwelderi.
Dicellomus parvus.
Acrothele minuta.
Gastropoda:
Straparollina, species undetermined.
Trilobita:
Agnostus chinensis, A. kusanensis.
Redlichia finalis, R. species undetermined.
Olenoides (?) cilix.
Dorypyge leblanci.
Damesella chione, D. sinensis.
Drepanura premesnili.
Ptychoparia (?) bromus, P. ceus, P. tenes.
Shanglungia spinifera.

Middle Cambrian....Chang Hsia formation.....

Foraminifera: *Globigerina (?) mantonsis.*
Porifera: *Protospongia chloris.*
Brachiopoda:
Obolus minimus, O. obscurus, O. shensiensis.
O. (Lingulella) chinensis, O. (L.) damesi.
O. (Lingulepis) eros.
O. (Westonia) blackwelderi.
Micrometra labradorica orientalis, M. pannula ophirensis.
Dicellomus parvus.
Acrothele matthewi eryx, A. varus.
Acrotreta liani, A. pavifera, A. shanglungensis.
Obolella asiatica.
Plectorthis linnarssoni.
Billingsella pumpellyi (?).
Gastropoda:
Scenella clotho.
Platyceras chronus.
Stenotheca (?) clavius, S. rugosa orientalis.
Pteropoda:
Hyolithes cybele.
Orthotheca cyrene dryas, O. daulis, O. delphus, O. doris.
Trilobita:
Agnostus chinensis, A. kusanensis.
Microdiscus orientalis.
Dorypyge bispinosa, D. richthofeni.
Dorypygella alastor, D. alcon, D. typicalis.
Damesella beltagranulata D. blackwelderi, D. brevicaudata.
Agraulos abaris, A. abrota, A. acalle, A. agenor, A. direc, A. diri, A. dolon, A. dryas.
Anomocare alcinoe, A. biston, A. (?) bates, A. daulis, A. daunus, A. dreelus, A. latilimbatum, A. minus, A. tatian, A. temenus.
Anomocarella albion, A. (?) bura, A. chinensis.
Arionellus agonius, A. ajax, A. alala.
Menocephalus acerius, M. acis, M. admeta, M. adrastia, M. agave, M. belenus, M. species undetermined.
Pterocephalus asiatica.
Ptychaspis acamus, P. sp.

Middle Cambrian....Chang Hsia formation	Trilobita—Continued. *Ptychoparia frequens, P. tellus, P. teres, P. titiana, P. theano, P. tolus.* *P. (Liostracus) megalurus, P. (L.) thraso, P. (L.) toxeus, P. (L.) trogus, P. (L.) tutia.* *P. (Proampyx)* sp. *Solenopleura abderus, S. acantha, S. acidalia, S. agno.* *Crepicephalus damia, C. magnus.* *Dolichometopus alceste, D. deois, D. derceto, D. dirce.* Ostracoda: *Bradoria bergeroni, B. engo, B. eris, B. fragilis, B. stercope, B. woodi.*
Lower Cambrian.....Man To formation	Brachiopoda: *Obolella asiatica.* *Billingsella pumpellyi (?), B. richthofeni.* Gastropoda: *Stenotheca rugosa chinensis.* Pteropoda: *Hyolithes delia.* Trilobita: *Redlichia chinensis, R. nobilis.* *Ptychoparia actis, P. constricta, P. granulosa, P. impar* var., *P. mantoensis.*
Pre-Cambrian.....Tai Shan Complex.	

TABLE SHOWING GEOLOGIC AND GEOGRAPHIC DISTRIBUTION OF THE FAUNA.

	Horizons.			Localities.							
	Cambrian.			Near Yen Chuang.	Near Chang Hsia.	Chen Ping Hsien.	Near Chao Mi Tien.	Ting Hsiang Hsien.	Tai An Fu.	Kao Chia Pu.	Hsin Tai Hsien.
	L.	M.	U.								
FORAMINIFERA.											
Globigerina mantoensis, new species				×							
PORIFERA.											
Protospongia chloris, new species											
BRACHIOPODA.											
Obolus matinalis Hall									×		
minimus Walcott		×		×							
obscurus Walcott		×									
shensiensis Walcott		×				×		×			
species undetermined									×		
Obolus (*Lingulella*) *chinensis* Walcott		×		×							
Obolus (*Lingulella*) *davisi* Walcott		×									
Obolus (*Lingulepis*) *eros* Walcott		×		×							
Obolus (*Westonia*) *blackwelderi* Walcott		×							(?)		
Dicellomus parvus Walcott		×		×		×					
Micromitra labradorica orientalis Walcott		×									
Micromitra pannula ophirensis Walcott		×									
Acrothele matthewi eryx, new variety		×		×							
minuta Walcott		×		×							
rarus Walcott		×			(?)					×	
Acrotreta lini Walcott		×			×						
pacifica Walcott		×		×							
shangtungensis Walcott		×		×				×			
Craniella?? sp.			×						×		
Obolella asiatica Walcott	×	×			×	×					
Smitrophia orientalis Walcott			×	×					×		
orthia, new species			×						×		

TABLE SHOWING GEOLOGIC AND GEOGRAPHIC DISTRIBUTION OF THE FAUNA—Cont'd.

	Horizons.			Localities.							
	Cambrian.			Near Yen Chuang.	Near Chang Hsia.	Chen Ping Hsien.	Near Chao Mi Tien.	Ting Hsiang Hsien.	Tai An Fu.	Kao Chia Pu.	Hsin Tai Hsien.
	L.	M.	U.								
BRACHIOPODA—continued.											
Plectorthis doris Walcott			×	·							
kayseri Walcott			×	×							
linnarssoni Walcott		×	×	·	×				×		
pagoda Walcott			·				·		·		
species undetermined			·						·		
Billingsella pumpellyi Walcott	(?)		·	·	(?)		·				
richthofeni Walcott	·			×							
GASTROPODA.											
Scenella clotho, new species					·						
species undetermined			×						·		
Straparollina circe new species			×						×		
species undetermined		·									
Platyceras chronus, new species		×		·	×						
elytin, new species							×				
pagoda, new species			×						×		
Stenotheca(?) clarius, new species		·					·				
rugosa chinensis, new variety	·										
rugosa orientalis, new variety		·									
species undetermined			·						·		
PTEROPODA.											
Hyolithes cybele, new species		·		·	×						
daphnis, new species			·	·							
delia, new species	×			·							
Orthotheca cyrene, new species			·				×				
cyrene dryas, new variety		·		·							
daulis, new species		×		·	·						
delphus, new species		·		·						·	
doris, new species		·			·						
species undetermined			·						·		
CEPHALOPODA.											
Cyrtoceras cambria, new species			·						·		
TRILOBITA.											
Agnostus chinensis Dames		·	×	·			·		×	·	
kusanensis, new species		·								·	
Microdiscus orientalis, new species		·				×					
Redlichia chinensis, new species	×				·						
finalis, new species		·								×	
nobilis, new species	·			·							
species undetermined	×				·						
species undetermined	×				×						
species undetermined		×		·					×		
Olenoides (?) cilix, new species		×									
Dorypyge bispinosa, new species		×		·							
leblanci Berg		×		·					×		
richthofeni Dames		×		·		×				×	
Dorypygella alastor, new species		×		×							
alcon, new species		×		·							
typicalis, new species		·		×							
Damesella bellagranulata, new species		·									
blackwelderi, new species		·									
brevicaudata, new species		×			×						
chione, new species		×		·							
sinensis Berg		×		·							

TABLE SHOWING GEOLOGIC AND GEOGRAPHIC DISTRIBUTION OF THE FAUNA—Cont'd.

	Horizons.			Localities.							
	Cambrian.			Near Yen Chuang.	Near Chang Hsia.	Chen Ping Hsien.	Near Chao Mi Tien.	Ting Hsiang Hsien.	Tai An Fu.	Kao Chia Pu.	Hsin Tai Hsien.
	L.	M.	U.								
TRILOBITA—continued.											
Drepanura premesnili Berg		×		×					×		
Agraulos abaris, new species		×		×							
abrota, new species		×			×						
acalle, new species		×		×							
agenor, new species		×			×						
dirce, new species		×									×
divi, new species		×		×							
dolon, new species		×		×							
dryas, new species		×			×						
Anomocare alcinoe, new species		×								×	
bergioni, new species			×								×
bianos, new species			×	×							
biston, new species		×		×							
butes, new species			×	×							×
dantis, new species			×		×						
damnus, new species		×		×							
decdus, new species		×		×							
latilimbatum Dames		×		×							
minus Dames		×		×							
tatian, new species		×			×						
temenus, new species		×		×	×						
Anomocarella albion, new species		×		×						×	
baucis, new species			×				×				
bura, new species		×			×						
carme, new species			×				×				
chinensis, new species		×		×						×	
Arionellus agonius, new species		×		×							
ajax, new species		×		×							
alata, new species		×		×	×		×				
Monocephalus accrius, new species		×			×						
acis, new species		×					×				
admota, new species		×			×						
adrastia, new species		×			×						
agave, new species		×			×						
belenus, new species		×			×						
(?) *depressus*, new species			×				×		×		
species undetermined		×		×							
Pagodia bia, new species			×				×		×		
dolon, new species			×				×				
lotos, new species			×						×		
macedo, new species			×				×				
Pterocephalus asiatica, new species		×		×							
busiris, new species			×	×					×		
Ptychaspis acamus, new species			×				×				
cacus, new species			×	×							
cadmus, new species			×				×				
calchas, new species			×				×				
callisto, new species			×	×							
calyce, new species			×				×				
campe, new species			×				×				
ceto, new species			×	×			×		×		
species undetermined		×					×				
species undetermined			×				×				
species undetermined			×				×				
Ptychoparia actis, new species	×				×						
(?) *batia*, new species			×				×				×
(?) *bromus*, new species		×									
cens, new species		×									
constricta, new species	×										
dryope, new species			×						×		

TABLE SHOWING GEOLOGIC AND GEOGRAPHIC DISTRIBUTION OF THE FAUNA—Cont'd.

	Horizons.			Localities.							
	Cambrian.			Near Yen Chuang.	Near Chang Hsia.	Chen Ping Hsien.	Near Chao Mi Tien.	Ting Hsiang Hsien.	Tai An Fu.	Kao Chia Pu.	Hsin Tai Hsien.
	L.	M.	U.								
TRILOBITA—continued.											
Ptychoparia frequens, Dames		×		×							
granulosa, new species	×										
impar, new species	×				×						
impar var.? new variety	×				×						
ligea, new species	×				×						
mantoensis, new species	×				×						
tellus, new species		×		×							
tenes, new species		×			×					×	
titiana, new species		×		×	×						
thoano, new species		×					×				
tolus, new species		×									×
species undetermined		×								×	
Ptychoparia (*Liostracus*) *megalurus* Dames		×						×			
Ptychoparia (*Liostracus*) *thraso*, new species		×		×			×				
Ptychoparia (*Liostracus*) *toxeus*, new species		×			×						
Ptychoparia (*Liostracus*) *trogus*, new species		×			×						
Ptychoparia (*Liostracus*) *tutia*, new species		×			×		×				
Ptychoparia (*Proampyx*) *barca*, new species			×	×							
Ptychoparia (*Proampyx*) sp.		×		×							
Shangtungia spinifera, new species		×		×							
Solenopleura abderus, new species		×			×						
acantha, new species		×			×						
acitalia, new species		×			×						
agno, new species		×			×						
belus, new species			×						×		
beroe, new species			×	×							
Dikelocephalus (?) *baubo*, new species			×	×							
Dikelocephalus (?) *brizo*, new species			×						×		
Crepicephalus damia, new species		×			×						
magnus, new species		×			×		×				
Dolichometopus alceste, new species		×		×							
decis, new species		×		×	×					×	
derceto, new species		×		×							
dirce, new species		×			×						
Illaenurus canens, new species							×		×		
ceres, new species			×				×				
dictys, new species			×						×		
OSTRACODA.											
Bradoria bergeroni, new species		×				×					
cuyo, new species		×				×					
cris, new species		×				×					
fragilis, new species		×				×					
stereope, new species		×				×					
woodi, new species		×				×					

FORAMINIFERA.

Genus GLOBIGERINA d'Orbigny.

GLOBIGERINA (?) MANTOENSIS, new species.

A single specimen of what is probably a species of Foraminifera occurs in a compact gray limestone. It is elongate-oval in shape, convex, and divided longitudinally by a narrow furrow into two lobes, which are marked by more or less irregularly arranged and not very deep depressions at right angles to the central furrow.

Formation and locality.—Middle Cambrian, upper portion of Man To shale formation; 3.2 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PORIFERA.

PROTOSPONGIA Salter.

PROTOSPONGIA CHLORIS, new species.

Of this species only the large primary spiculæ are known. The skeleton is not preserved. The silicious spicules vary in size, but they all appear to be four-rayed. The rays are slender, extending out usually at right angles to each other from the center, but in some specimens one or more of the rays is occasionally slightly diverted from the right angle; they slope slightly downward from the center to their extremities, which gives a low pyramidal form to the spicule; there is no trace of a central, downward-pointing ray on the under side. Each ray has a rounded angle on its upper side; it is slightly angular at the sides and subangular on the lower side. In many examples the narrow rounded ridge of the upper side is exfoliated, leaving a V-shaped groove lengthwise of the ray; the grooves from the four rays unite at the center.

As a result of the exfoliation of the upper side of the ray there appear to be three forms of spicules: First, the complete spicule, as above described; second, a very slender spicule with the rays rounded on the upper side and angular on the lower side; and, third, a spicule having a V-shaped groove on the upper side of the rays.

The spicules above described resemble in general form those of *Protospongia fenestrata* Salter; they differ in the absence of the central ray and the exfoliation of the upper side of the ray.

Formation and locality.—Middle Cambrian, central portion of Chang Hsia formation, in compact gray limestone; at Yen Chuang and 2 miles south and 3 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

BRACHIOPODA.

Genus ACROTHELE Linnarsson.

ACROTHELE MATTHEWI ERYX, new variety.

In form, convexity, and size the ventral valve of the only specimen representing this variety is very similar to the typical forms of *Acrothele matthewi*. The shell is partially exfoliated, and shows the cast of the boss as a small oval pit about the pedicle opening and two narrow vascular sinuses that extend from a point nearly back of the pit, forward and a little outward, about one-third the length of the valve.

The shell is built up of several layers of lamellæ that are smooth and shiny on the interior, except where slightly roughened by slight vascular markings and obscure radiating striæ; the outer surface is dull and marked by concentric striæ and lines of growth and numerous fine, irregular, often anastomosing, elevated lines that give the surface a rough appearance.

The valve is nearly circular, with a diameter of 6 mm. If this shell were associated with *Acrothele matthewi* in the Middle Cambrian rocks of New Brunswick, I should not hesitate to identify it with that species. In the absence of a series of specimens and specimens of the dorsal valve, it is not certain that it is identical with *Acrothele matthewi*. On this account the varietal name is given it.

Formation and locality.—Middle Cambrian, central portion of Chang Hsia formation; 3 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus SYNTROPHIA Hall and Clarke.

SYNTROPHIA ORTHIA, new species.

General form irregularly oval, with the ventral view obtusely angular toward the apex; rounded, biconvex, with a deep mesial sinus at the ventral valve and a strong median fold on the anterior half of the dorsal valve.

Surface smooth with the exception of a few concentric striæ and lines of growth.

The ventral valve has a strong median sinus that occupies about one-third of the width of the valve at the anterior margin and projects forward to fit into the sinus in the front of the margin of the dorsal valve; the sides of the median sinus are elevated, and with the downward curving lateral slopes form a strong, rounded ridge on each side of the sinus; none of the specimens in the collection show the area, but from the profile of the valve it must have been of moderate height with a rather sharp apex curving over it.

Dorsal valve with a minute apex from which a narrow, slightly developed median fold extends out to about the center of the shell, where it becomes elevated and projects forward to the front margin; the remaining portions of the surface are uniformly convex, sloping away from the median fold to the margins of the valve.

Nothing is known of the interior of either valve.

Observations.—In general form this species resembles *Syntrophia primordialis* of the St. Croix sandstone of Wisconsin.[a] It differs in its more rounded irregularly oval form and the very large median sinus of the ventral valve.

Formation and locality.—Upper Cambrian. Central portion of Chao Mi Tien limestone, Pagoda Hill, 1 mile southwest of Tai An Fu, and at a somewhat lower horizon two-thirds of a mile west of Tai An Fu, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

GASTROPODA.

Genus SCENELLA Billings.

SCENELLA CLOTHO, new species.

Shell small, moderately convex; apex elongate, slightly eccentric, elevated; aperture irregularly oval; a narrow carina extends from the apex down to the broader end, and several obscure carinæ radiate from the apex toward the margin.

Surface marked by fine concentric striæ and very fine radiating striæ.

The type specimen has a length of 4.25 mm.; greatest width 3 mm.; elevation of apex about 1.5 mm.

This species is clearly distinguished by the broad, elliptical, or subovate form of its aperture and elongated apex; the latter feature is determined from the interior of the shell, which indicates that the apex was situated somewhat nearer the narrower end of the aperture; this feature suggests that if there were perfect specimens representing the species, it might be found to be more nearly related to some forms of *Stenotheca* than to *Scenella*.

Formation and locality.—Middle Cambrian, upper portion of Chang Hsia formation, 1 mile east of Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

SCENELLA, species undetermined.

This species is represented by a cast of the interior of a small, patelloid shell, with an oval aperture measuring 2 by 3 mm. and

[a] Proc. U. S. Nat. Mus., XXVIII, 1905, p. 292.

having a slightly eccentric elevated apex. It does not appear to be identical with *Scenella clotho*, of the Chang Hsia formation, as the apex is more eccentric and there is no evidence of any carinæ.

Formation and locality.—Upper Cambrian, lower portion of Chao Mi Tien formation; Pagoda Hill, 1 mile west-southwest of Tai An Fu, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus STRAPAROLLINA Billings.

STRAPAROLLINA CIRCE, new species.

Shell small, hemispherical, spire depressed and rounded in outline; whorls probably about three; only two are preserved; suture shallow; the whorls are gently and uniformly rounded from the suture down to the more rapid curve to the basal side; as far as can be determined a section of the outer whorl has the form of an ellipse, the narrower parts toward the dorsal furrow and the outer basal margin.

The greatest diameter of the type and only specimen is 3.5 mm.; greatest diameter near aperture 2 mm.; diameter of whorl opposite aperture 1.5 mm.

The surface is marked by concentric elevated lines that extend obliquely backward from the dorsal suture to the base of the whorl, where they are concealed by the matrix. This species differs from *Straparollina remota* Billings in the more rapid expansion of the outer whorl and more elevated spire.

Formation and locality.—Upper Cambrian, lower portion of Chao Mi Tien formation; Pagoda Hill, 1 mile west-southwest of Tai An Fu, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

STRAPAROLLINA, species undetermined.

This form is represented by the lower portion of a single whorl, that is rounded in outline and suggestive of *Straparollina remota*. The greatest diameter across the volution is 6.5 mm., and of the whorl 2.5 to 3 mm.

Formation and locality.—Middle Cambrian, in shales just below the Chao Mi Tien formation, corresponding to the Ku San shales; isolated hills 12 miles S. 80° E. of Tai An Fu, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus PLATYCERAS Conrad.

PLATYCERAS CHRONUS, new species.

Shell minute, consisting of two whorls somewhat irregularly incurved, the inner whorl being on the plane of the dorsal (outer) side; the outer whorl expands rapidly toward the aperture, increasing more on the right ventral (inner) side; a cross section of the outer whorl shows the outer side to be slightly convex and the inner side strongly convex, a rather sharp dorsal angle being formed where the two unite on the outer side.

A narrow, sharp ridge occurs about midway of the outer side of the whorl, that is seen only when the outer surface is very perfectly preserved; in one example the ridge has a narrow depression on the outer side which makes a rather prominent feature of the surface; the striæ of growth arch backward to this ridge, indicating a sharp but small dorsal sinuosity in the peristome; on casts of the interior neither the ridge nor the arching backward of the striæ is shown.

The surface of finely preserved specimens is marked by concentric lines of growth, a sharp ridge, and one or two very fine, elevated lines subparallel to the ridge.

Greatest diameter of shell 1.5 mm.; dorso-ventral diameter of whorl at aperture 0.75 mm.; lateral diameter 0.5 mm.

This species appears to be most nearly related to *Platyceras primævum* Billings. It differs in its stronger dorsal angle and more rapidly expanding outer whorl.

Formation and locality.—Middle Cambrian, central portion of Chang Hsia formation; at Yen Chuang and 2.5 miles south of Yen Chuang; also in cliffs 1 mile east of Chang Hsia, in upper portion of Chang Hsia formation; Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PLATYCERAS CLYTIA, new species.

Shell minute, consisting of about two whorls. Whorls regularly incurved, the plane of the coiling being nearly perfect with the exception of a very slight inclination to the left when looking down upon it from above (dorsally). Outer whorl very minute at origin, increasing slightly for the first half of its turn and then rapidly toward the aperture, which is rounded ovate, being narrowest at the dorsum; a rounded dorsal ridge is formed on the outer whorl by the convex slope of the two sides meeting at the dorsum.

Surface apparently smooth in the half dozen specimens in the collection.

Greatest diameter 2.75 mm.; dorso-ventral diameter of whorl near aperture 1.5 mm.; greatest lateral diameter 1.25 mm.

This species differs from *Platyceras chronus* and *P. pagoda* in the form of the outer whorl, which expands more uniformly and has a broadly ovate section; its form also distinguishes it from *P. primævum*.

Formation and locality.—Upper Cambrian, upper portion of Chao Mi Tien formation, in gray oolitic limestone: Chao Mi Tien, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PLATYCERAS PAGODA, new species.

Shell minute, consisting of about two whorls, of which the inner whorl is very minute and incurved so as to be seen best from the right dorsal or outer side. Whorls regularly incurved, with the plane of the coiling toward the right dorsal side. The section of the outer whorl near the aperture is elongate oval, with the left ventral side somewhat flattened. The outer whorl widens rapidly toward the aperture, especially on the right ventral (inner) side, which gives the outline, when looked at from the dorsal ridge, an oblique, unsymmetrical appearance.

Surface marked by concentric lines of growth which arch backward upon the dorsum, indicating a dorsal sinuosity in the peristome.

Greatest diameter of the shell 2.5 mm.; dorso-ventral diameter of whorl near the aperture 1.75 mm.; greatest lateral diameter not measurable, but apparently not more than one-half the antero-posterior diameter.

This species differs from *Platyceras chronus* in the size of the outer whorl, minute inner whorl, and the absence of longitudinal ridges, features which also distinguish it from *P. primævum* Billings[a] and allied forms.

Formation and locality.—Upper Cambrian, lower portion of Chao Mi Tien formation: Pagoda Hill, 1 mile west-southwest of Tai An Fu, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus STENOTHECA Salter

STENOTHECA (?) CLURIUS, new species.

This form is represented by the interior cast of a large, slender, slightly curving shell. The cast has a length of 16 mm., with a diameter where it is broken off at the end of 4 by 5 mm. The largest diameter at the aperture was probably about 10 mm.

[a] Can. Nat. and Geol., VI, 1871, p. 220.

The generic reference of this specimen is doubtful, but in the absence of the outer shell it is not possible to determine the generic relations.

Formation and locality.—Upper Cambrian, lower portion of Chao Mi Tien formation; Pagoda Hill, 1 mile west-southwest of Tai An Fu, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

STENOTHECA RUGOSA CHINENSIS, new variety.

In its general form this shell is closely related to *Stenotheca rugosa;* it is, however, more elevated and more broadly oval in outline than the typical forms of *S. rugosa*. The surface is marked by a number of moderate undulations, or low concentric ridges, and numerous very fine concentric striæ of growth; with a strong lens fine radiating striæ are visible. The type and only specimen in the collection has a longer diameter at the aperture of about 10 mm., with a height of 7 mm. to where the apex is decorticated; at this point the oval section has a length of 2.5 mm., with a width of 1.5 mm. The apex is broken off at a smooth, slightly convex septum.

This specimen is of unusual interest, owing to the presence of a septum toward the apex. In form it resembles most closely *S. rugosa acuticosta* Walcott, but differs from that variety in the presence of rounded instead of acute costæ. From *S. rugosa* it differs in being elevated and more or less conical.

Formation and locality.—Lower Cambrian, Man To formation, in a hard, blue-gray limestone, 2.5 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

STENOTHECA RUGOSA ORIENTALIS, new variety.

This variety is founded upon a small, slender shell with a rounded, oval aperture. In form it is between *Stenotheca rugosa acuticosta* and *S. rugosa erecta*, being slender, slightly arched, and cornucopia-like. Surface marked by strong, sharply angular concentric ridges, with broader U-shaped furrows between them, and numerous fine concentric striæ. The average length of the shells of this species is 3 mm., with a diameter at the aperture of 1.5 to 1.75 mm.

Formation and locality.—Middle Cambrian, upper portion of Chang Hsia formation; at Chang Hsia and 1 mile east of Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTEROPODA.

Genus HYOLITHES Eichwald.

HYOLITHES CYBELE, new species.

Form an elongate, subtriangular pyramid, gradually and regularly tapering to an acute extremity. The apical angle of the dorsal side is about 15°. Transverse section rounded subtriangular; the ventral angle is rounded and the lateral angles slightly rounded off. Dorsal face moderately convex and curving very slightly from the apex to the anterior, spatulate portion. Ventral face strongly and regularly convex transversely. Aperture oblique, the margin extending on the dorsal side; the peristome on the ventral side is slightly curved forward.

Surface marked by concentric, transverse, more or less obscure lines and striæ of growth; the cast of the interior shows on the ventral face three or four obscure longitudinal lines, the central one of which is the strongest.

The largest specimen in the collection has a length of 24 mm., with a width of 7 mm. at the aperture.

The body of the associated operculum is semicircular, moderately convex on the outer side externally, and concave within. The ventral wing as seen on the outside is semicircular-convex, rising toward a point at the center of the transverse side. The dorsal limb is nearly flat, rising, as far as can be determined from a broken specimen, at an angle of about 100° from the plane of the body of the operculum.

In the slope of the sides toward the apex, character of surface, and the transverse section this species may be compared with *Hyolithes princeps* Billings,[a] of the Lower Cambrian of Newfoundland, *H. tenuistriatus* Linnarsson, and *H. arenophilus* Holm.[b] *H. cybele* is, however, much smaller than the first two species mentioned, and its section is much more convex, both on the dorsal and ventral sides, than that of *H. arenophilus*.

Formation and locality.—Middle Cambrian, central portion of Chang Hsia formation; at Yen Chuang, 2 miles and 2.5 miles south and 3 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China. Also near the top of the Chang Hsia formation at Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

[a] Tenth Ann. Rept. U. S. Geol. Survey, 1890, pl. LXXVI, figs. 1 to 1 *a*.

[b] Geol. Surv. Sweden, Ser. C, No. 112, pl. 1, figs. 78–81 and 82–93.

HYOLITHES DAPHNIS, new species.

The type and only specimen of this species in the collection has a length of 26 mm., with a width at the larger end on the dorsal side of 11 mm., and a dorso-ventral thickness of 9 mm. At a distance of 21 mm. from the larger end the smaller end has a width of 5 mm. on the dorsal side. Nothing is known of the outer surface. The section shows a very strongly convex ventral side, with rounded ventral angle; the dorsal side is gently convex, with the lateral angle slightly rounded.

This species is represented by a cast that might have been taken from some of the more convex specimens of *Hyolithes princeps* Billings, of the Lower Cambrian rocks of Newfoundland. It differs from these in the more convex dorsal side.

Formation and locality.—Upper Cambrian, summit of the Chao Mi Tien formation; 2.7 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

HYOLITHES DELIA, new species.

This species is represented by the dorsal side of a single specimen. It resembles the dorsal side of *Hyolithes billingsi* Walcott.[a] The dorsal surface is gently convex and is marked on each side, parallel to and a little distance within the margin, by a very shallow groove which outlines a central, more slightly convex area. This specimen is probably the interior cast. It shows a few forward-arching concentric lines of growth. The type and only specimen representing the species has a length of 5 mm., with a width of 1 mm. at the smaller end and 2.25 mm. at the larger end.

From the means of comparison afforded by the single specimen this species appears to be most closely related to *Hyolithes billingsi*. It differs in the more slender tube.

Formation and locality.—Lower Cambrian, in hard, blue-gray limestone, lower part of Man To formation; 2.5 miles south of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus ORTHOTHECA Novak.

ORTHOTHECA CYRENE, new species.

Form an elongate, slender, subtriangular tube, with the lateral margin rounded, tapering gradually from the base to an acute extremity.

[a] Bull. No. 30, U. S. Geol. Survey, 1886, p. 134, pl. XIII, figs. 1*b*, 1*c*.

Transverse section rounded subtriangular, transverse, and slightly concave toward the center on the dorsal side, rounded at the lateral angles, highly arched on the ventral side, with the ventral angle broadly rounded. Dorsal face of the lateral angles rounded, with a shallow depression, with rounded lateral slopes, a little more than one-third the width of the face. Ventral face strongly and regularly convex transversely, and without any ventral angle. Aperture, as far as known, transverse, at right angles to the axis of the shell. Operculum unknown. Shell of moderate thickness and made up apparently of several layers or lamellæ.

Surface of the shell concentrically or transversely finely striated; a few longitudinal striæ may be seen by turning the specimen in the light.

The largest specimen, which is broken off at the apical end, has a length of 9 mm., with a width on the dorsal side at the larger end of 2 mm.; a specimen with a diameter of 3 mm. on the dorsal face has a dorso-ventral diameter of 2 mm.

What appears to be a transverse septum occurs in one of the shells about 9 mm. from the apical end.

The elongate form of the tube and the shallow groove on the center of the dorsal face are not unlike *Hyolithes communis cumonsi* Ford.[a] The two species, however, differ in the outline of the transverse section and in the more rapidly expanding tube of *Orthotheca cyrene*. There is a number of species from the Swedish Cambrian, illustrated by Holm, that have the central depression on the dorsal face. Of these *Orthotheca affinis* Holm is most nearly related to *O. cyrene*.

Formation and locality.—Upper Cambrian, upper portion of Chao Mi Tien formation; Chao Mi Tien and 2.7 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ORTHOTHECA CYRENE DRYAS, new variety.

This variety is characterized by having a broader, more shallow furrow on the dorsal face; otherwise it appears to be identical with *O. cyrene*. On some specimens the shallow groove is scarcely perceptible, the face being practically transverse and smooth.

Formation and locality.—Middle Cambrian, central portion of Chang Hsia formation; 2 miles south of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

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[a] Tenth Ann. Rept. U. S. Geol. Survey, 1890, pl. LXXVII, fig. 4*b*.

ORTHOTHECA DAULIS, new species.

Shell elongate, slender, tapering gradually to an acute point. Transverse section subcircular, slightly flattened on the dorsal side. Ventral face strongly and regularly convex transversely; the dorsal and ventral faces meet to form the rounded lateral angles of the shell, the dorsal face being narrow and slightly flattened. Aperture transverse, as indicated by the transverse lines of growth.

Surface of the shell smoothed and polished, with only a very few obscure traces of transverse concentric lines of growth.

The largest specimen in the collection has a length of 16 mm., with a diameter at the larger end of 4 mm., and at the smaller end, where it appears to be broken off at a transverse septum, of 1.25 mm.

This species resembles, in its slender tube and nearly circular section, *Orthotheca communis* Billings.[a] It differs in expanding a little more rapidly toward the larger end and in its smooth surface. It may be compared with *Orthotheca stylus* Holm, except that it does not have the curvature of that species nor the cancellated surface. Its slender tube and nearly circular section are much like those of *Orthotheca tenuiseulus* Linnarsson,[b] as illustrated by Holm in his memoir on Hyolithidæ.

Formation and locality.—Middle Cambrian, lower portion of Chang Hsia formation, in gray oolitic limestone; 50 feet below base of cliffs, Chang Hsia; also central portion of Chang Hsia formation, 2.2 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ORTHOTHECA DELPHUS, new species.

Shell straight, elongate, slender, tapering gradually to an acute point. Transverse section subelliptical, with the dorsal side flattened. Dorsal face gently convex, lateral angles rounded. Ventral face moderately convex. Aperture about transverse, as indicated by the concentric striæ and lines of growth. Shell of medium thickness.

Surface of the shell transversely or concentrically striated by somewhat irregular, raised, sharp, fine, closely arranged striæ; on the rounded ventral side a few slightly oblique, longitudinal, elevated lines occur near the larger end.

The largest specimen has a length of 9 mm., with a width of 1 mm. at the smaller end and 1.75 mm. at the larger end.

There is some variation in the transverse section of the shell owing to the variation in the convexity and flattening of the dorsal face. In some specimens toward the apical end the section is a rather narrow ellipse.

[a] Tenth Ann. Rept. U. S. Geol. Survey, 1890, pl. LXXVII, figs. 3, 3 *a–g*.

[b] Geol. Surv. Sweden, Ser. C, No. 112, pl. I.

The elliptical section and the fine, raised, transverse striæ serve to distinguish this species from any other known to me.

Formation and locality.—Middle Cambrian, central portion of Chang Hsia formation, in limestone nodules at the base of a stratum of green shale, a local phase of the Chang Hsia oolite formation; 3 miles south of Kao Chia Pu and 3 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ORTHOTHECA DORIS, new species.

Shell elongate, slender, and regularly tapering. Transverse section oval or circular; in the type and only specimen the shell is somewhat crushed, which leaves the original form in doubt. The dorsal face appears to have been moderately convex, with rounded lateral angles that pass into the convex, rounded ventral side. Transverse striæ and lines of growth indicate that the aperture was probably transverse. Shell apparently strong.

Surface of shell transversely or concentrically marked by lines of growth, with more or less irregular striæ between them; in addition there is a finely pitted surface between the striæ, and sometimes on them, that gives a very peculiar aspect to the surface under a strong lens.

The fragment representing this species has a length of 7.5 mm., with a transverse diameter at the larger end of 5 mm.

This species is characterized by the peculiar, irregularly pitted surface.

Formation and locality.—Middle Cambrian; collected from river drift rock on gravel bar in the Lan Hö, 1 mile south of Chên Ping Hsien, southeastern Shensi, China, near the extreme southeastern corner of the Province of Shensi, adjoining on Hupeh and Ssuch' uan.

Collected by Bailey Willis and Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ORTHOTHECA, species undetermined.

Fragments of a small, elongate, slender Orthotheca occur in the upper Cambrian. The species has a transverse section much like that of *O. daulis*, except that the dorsal face is much broader, which gives a rounded, subtriangular outline to the section, resembling in this respect *O. cyrene*, but the latter has a shallow groove on the dorsal face which is absent in the fragments under consideration.

Formation and locality.—Upper Cambrian, upper part of Chao Mi Tien formation; Pagoda Hill, 1 mile west-southwest of Tai An Fu, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

CEPHALOPODA.

Genus CYRTOCERAS Goldfuss.

CYRTOCERAS CAMBRIA, new species.

Shell gently curved, laterally compressed. Section ovate, dorso-ventral diameter as compared with the lateral diameter toward the last chamber being nearly as four to three, the greatest lateral diameter being nearer the dorsal than the ventral side; dorsal side more obtusely rounded than the ventral. Septa arching slightly forward from the dorsal side; short, about five in a distance of 2.5 mm. where the shell has a diameter of from 1 to 1.5 mm. Chamber of habitation supposed to be of moderate depth; none of the specimens clearly show the margin of the aperture.

This species is represented by a number of more or less fragmentary specimens. The largest has a dorso-ventral diameter near the aperture of 3 mm., with a length of 7 mm. to where the diameter is 1.25 mm.; chamber of habitation appears to have a depth of 2 mm. The siphuncle in a specimen 2.25 mm. in the dorso-ventral diameter has a diameter of less than 0.2 mm.; it is situated on the dorsal side, and almost reaches the exterior surface of the thin shell, which is somewhat thickened on the dorsal side.

This little shell appears to be a true Cyrtoceras. Occurring as it does well down toward the base of the Chao Mi Tien limestone, the fauna of which is of upper Cambrian age, makes it of great interest, as it is the oldest known representative of the genus, and, unless Volborthella is considered to be a cephalopod, is the oldest known representative of that class.

Formation and locality.—Upper Cambrian, lower portion of Chao Mi Tien limestone; Pagoda Hill, 1 mile west-southwest of Tai An Fu, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

TRILOBITA.

Genus AGNOSTUS Brongniart.

AGNOSTUS KUSANENSIS, new species.

Cephalic shield moderately convex, a little wider than long, semicircular in outline, and slightly contracted at the posterior lateral angles; the narrow, rim-like, rounded border is broadest at the front, narrowing toward the postero-lateral angle, around which it curves, and extends about one-fourth the distance across the posterior margin of the head; dorsal furrow well defined on the sides, but rather faint in front of the large posterior lobe of the glabella.

The glabella is formed of a posterior, slightly convex lobe that is little more than one-fourth the width of the head and less than one-half its length; it is marked a little in advance of its center by a small, pointed tubercle; in front of the posterior lobe there is a faintly outlined conical extension of the glabella that differs more or less in form and strength in nearly every specimen of the head; it is usually very obscure; lateral lobes moderately convex and uniting in the front without interruption in the convexity or surface.

The thoracic segments associated with the cephalic and caudal shields have a convex axial lobe with narrow pleural lobes; the axial lobe is divided into a central portion and two lateral portions by narrow furrows, giving the effect of two large oval tubercles between the dorsal furrow and the central portion of the segment; the short pleural lobe is marked by a very narrow pleural furrow a short distance back of its center.

The caudal shield associated with the cephalic shield is slightly shorter in proportion to its width and less convex; it is bordered by a flat, rather broad rim, that is narrow at the front margin, gradually increasing to its greatest width behind, where its inner margin curves inward to form a blunt angle at the point opposite the axial lobe; the front margin is narrow and elevated in front of the lateral lobes and bordered with a narrow, slightly convex, sharply defined axial segment.

Axial lobe about one-third the entire width, moderately convex, and marked on its anterior third by an elongate, slightly elevated tubercle from which on some specimens, but not on others, two very faint grooves extend outward and then curve obliquely backward to the dorsal furrow, the front groove being opposite the apex of the tubercle; in some examples the axial lobe contracts opposite the central tubercle and expands at the frontal margin, where an oblique, very faintly defined furrow outlines a small oval lobe; dorsal furrow narrow and sharply defined all about the central axis; back of the axis it unites and passes back into the furrow within the border; lateral lobes gently convex, usually about the width of the axial lobe near the central portions, narrowing posteriorly, and dying out at the short, shallow furrow at the posterior point of the axial lobe.

Surface of cephalic and caudal shields and thoracic segments minutely punctate.

This species differs from *Agnostus chinensis* Dames, which occurs abundantly in the Chang Hsia formation, in having a short glabella and broader lateral lobes on the cephalic shield, and broader lateral lobes and flat border on the pygidium. It is of the type of and very closely related to *A. parvifrons* Linnarsson, from which it differs in the proportion of the glabella to the length of the cephalic shield and in the flatter margins of the cephalic and caudal shields.

Formation and locality.—Middle Cambrian, upper portion of Chang Hsia formation, 3 miles south of Kao Chia Pu, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus MICRODISCUS (Emmons) Walcott.[a]

MICRODISCUS ORIENTALIS, new species.

There is in the collection but a single specimen of the matrix of a portion of the head of this species. This indicates the head to have been semicircular in outline, with a strong, rounded, frontal border, marked by ten or more transverse furrows, very much in the same manner as *M. connexus*. In front of the border there is a very narrow, slightly elevated rim.

Cheeks convex, and sloping from the center toward the narrow, sharp dorsal furrow about the glabella and to the furrow within the border of the head. A very narrow ridge extends just back of the antero-lateral angles of the glabella outward so as to disappear in the furrow within the outer border.

Glabella very narrow in front, gradually widening toward the base, and from the slight indication in the specimen is continued backward in an occipital spine; it is marked by two transverse, lightly impressed furrows, and what may be a faintly impressed occipital furrow.

This species shows characters that occur in two described forms: The border of the head and the occipital spine are much like those of *M. connexus;* the transverse furrows of the glabella recall those of some specimens of *M. speciosus*.

Its occurrence in the Cambrian rocks of China is most interesting.

The fossils associated in the bluish-gray limestone are *Acrotreta shangtungensis*, *Dicellomus parvus*, *Obolella asiatica*, *Obolus shensiensis*, *Hyolithes*, undetermined fragments of trilobites, and a small ostracod.

Collected by Bailey Willis and Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Formation and locality.—Middle Cambrian.

The type specimen is from dark, bluish-gray, compact limestone, in the river drift of the Lan Hö, near the extreme southeastern corner of the province of Shensi, joining on Hupeh and Ssuch' uan, one mile south of Chên Ping Hsien, Shensi, China.

Genus REDLICHIA Crossman.

Redlichia Crossman, Revue Critique, Paléozoologie, 1902, Sixième Ann., p. 52.
Haferia Redlich, Mem. Geol. Sur. India, new ser., I, 1901, p. 2.
Not *Haferia* Bittner, 1895.

[a] Bull. U. S. Geol. Surv., No. 30, 1886, p. 152.

Original description by Doctor Redlich: "The head shield is almost semicircular, slightly elevated, possesses movable cheeks and two long cheek-spines. The glabella is cylindrical, slightly contracted toward the middle, provided on each side with four lateral furrows. The palpebral lobes, which surround the glabella in one continuous curve, are completely separate from it and not confluent as in Olenellus. The facial sutures are well developed in all the specimens and, in consequence of this, free cheeks are present.

"The suture begins in the first quarter of the external margin (reckoned from the glabella), extends along the eyes, and toward the posterior margin is again directed outward. The fixed cheeks are very narrow, whilst the free cheeks, which are provided with long cheek-spines, are almost double the width.

"Of the thorax only isolated segments are preserved. The axial part is elevated; the pleurae are grooved ('*plevres à sillon*' of Barrande), and end in a backwardly directed spine.

"On the glabella the surface of the test shows fine backwardly directed ridges, which are, however, so fine that they are visible only under the lens. On the thickened margin they are also present, but so much stronger that they can easily be shown in the figure. The cheeks, even when highly magnified, show nothing of the sort, but at most a fine punctation, which, however, is mainly due to the structure of the test."

Doctor Redlich compares this form with the genera *Protolenus*, *Paradoxides*, and *Metadoxides*, but does not note its close resemblance to *Zacanthoides* of the Middle Cambrian fauna of Nevada.

In India the type species *R. noetlingi* occurs near the summit of the Cambrian series of formations. In China *R. nobilis* occurs near the base of the Man To formation, not far above the Archean complex. *R. chinensis* is found in the central portions of the Man To formations, and *R. finalis* occurs nearly 1,000 feet or more higher in the section near the top of the Chang Hsia formation. This distribution indicates that *Redlichia* is a Middle Cambrian genus; also that it may be in the upper portion of the Lower Cambrian, but with our present information this is somewhat doubtful, as the fauna of the Man To formation is not distinctly Lower Cambrian.

Genotype.—*Redlichia noetlingi* Redlich.

REDLICHIA CHINENSIS, new species.

This species differs from *Redlichia noetlingi*, the type of the genus from India, in its more conical glabella and smaller anterior lobe of the glabella; otherwise the two forms are very much alike, as far as can be determined by the present means of comparison. From *Redlichia nobilis* it differs in having a proportionately less cylindrical glabella and much larger anterior fixed cheeks.

The stratigraphic range of the species is from the lower to the central portions of the Man To formation.

Formation and locality.—Lower Cambrian. Man To formation. Bluish-gray shaly and thin-bedded limestone, south slope of Man To Shan at Chang Hsia and 2 miles south, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

REDLICHIA FINALIS, new species.

This species is represented by one imperfect head, several free cheeks, and several long spines similar to those occurring with *R. chinensis*, which were probably attached to a segment of the thorax as in *Zacanthoides typicalis* Walcott.[a] The fragment of the head indicates an almost cylindrical glabella and elongate eye lobe; the free cheek indicates a shorter anterior fixed cheek than that of *R. nobilis*. The material representing this species is imperfect, but the fact that it occurs near the top of the Chang Hsia limestone, 1,000 or more feet above *R. chinensis* and *R. nobilis*, in a strongly marked Middle Cambrian fauna, makes it desirable to give the form a specific name. It probably approaches the type of the genus *R. noetlingi* from India more closely than the other two species from China.

Formation and locality.—Middle Cambrian. Lower portion of Ku San formation. Shaly limestone. Two miles south-southeast of Kao Chia Pu, Shangtung, China.

REDLICHIA NOBILIS, new species.

This species is closely related to *Redlichia noetlingi;* it differs in the form of the posterior segment of the glabella and the somewhat less cylindrical form of the glabella.

From *Redlichia chinensis* it differs in its less tapering glabella and shorter anterior fixed cheeks.

As far as known, it occurs only in the lower portion of the Man To formation.

Formation and locality.—Lower Cambrian. Man To formation, in a hard bluish-gray limestone. Southeast slope of Hu Lu Shan, 2½ miles south of Yen Chuang, Hsin Tai, Shangtung, China.

REDLICHIA, species undetermined.

A large free cheek and two thoracic spines, much like those found with *R. chinensis*, are all that is known of this species. The angle of divergence of the lateral spine is much greater than in other species, and the stratigraphic horizon is higher in the section.

[a] Bull. U. S. Geol. Surv., No. 30, 1886, pl. xxv, fig. 2.

Formation and locality.—Middle Cambrian. Shaly limestone in upper portion of Ku San shale, 2.5 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus OLENOIDES Meek.

OLENOIDES (?) CILIX, new species.

This species is founded on a pygidium that is semicircular in outline, moderately convex, and with a spinose margin. Axis moderately convex, conical, with a broadly rounded posterior end. It is divided by three clearly marked, transverse, rounded furrows into a strong anterior ring, next to the thorax, two moderately convex rings, and a long terminal portion, which has a slight fourth depression, indicating a fourth ring. The posterior portion of the axis slopes rather rapidly down to the margin. Owing to an abrasion, the presence or absence of the nodes usually present at the end of the axis can not be determined.

Dorsal furrow rounded and shallow.

Pleural lobes flat for a short distance from the axis, and then curve gently downward to the border. They are marked by a deep anterior furrow within the narrow, anterior, elevated margin and three furrows that terminate at the margin. The furrows outline three rather broad, slightly convex segments and a posterior area opposite the postero-lateral angle of the axis. The border is practically a continuation of the slope of the segments and furrows of the pleural lobe. It is marked opposite the segments by five short, backward-pointing, flat, broad spines, and diagonally opposite the lateral angle of the axis by two long, strong, backward-extending spines. In addition, there are two short spines with broad bases back of the axis between the two long spines.

Outer surface unknown, as the crust has been removed by abrasion or solution.

The type and only specimen of the pygidium has a length of about 12 mm., with a width at the front margin of 19 mm.; the axis has a length of about 9 mm., with a width in front of 6 mm. and at the terminal segment of 3.5 mm.

This species is characterized by the two long posterior spines and the short, backward-extending lateral spines; the latter spines are essentially of the type occurring on the pygidium of *Peltura* and *Protopeltura*, but the general character of the pygidium and spines relate it to the group of trilobites here brought together under the genera *Dorypyge*, *Dorypygella*, *Damesella*, and *Olenoides*.

Formation and locality.—Middle Cambrian, in shales corresponding to the Ku San shale formation; isolated hills 12 miles S. 80° E. of Tai An Fu, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus DORYPYGE Dames.

DORYPYGE BISPINOSA, new species.

This species is based on a pygidium having a strong, broad axis, narrow pleural lobes, and two long, strong spines that project obliquely backward from the postero-lateral angle of the pygidium.

The central axis has a length of 10 mm., with a width at the anterior end of 6 mm. and at the posterior terminal lobe of 6 mm., narrowing slightly at the second and third rings; it is divided by three shallow, rounded, transverse furrows into three slightly convex rings and a terminal ring nearly as long as the two posterior rings; there is also a narrow anterior ring that connected the pygidium with the thorax; the terminal ring is convex and slightly overhangs the margin; a node or slight swelling is indicated on each side of the median line where the ring slopes abruptly down to the margin.

Dorsal furrow rounded and somewhat irregular.

Pleural lobes slightly narrower than the axis and arching from the dorsal furrow directly down to the border; the lobes are divided by three broad furrows into an anterior, marginal, elevated rim and two slightly concave segments; a third and posterior segment is indistinctly outlined; the furrows and segments terminate within a slightly thickened border. Three pairs of short spines occur on the border opposite the two anterior segments and frontal rim of the pleural lobe; opposite the faintly defined posterior segment there is a long, strong spine, and from the space between the latter spine and where the dorsal furrow intersects the border there is another longer and stronger spine that extends obliquely outward and backward.

The surface is marked by a few pustules that occur on the elevated portions of the rings of the axis and the pleural lobes; under a strong lens the crust appears to be slightly roughened and apparently minutely punctate.

Dimensions.—Length, 11 mm.; width at the anterior border, 16 mm.; width of axis, 6 mm.; width of pleural lobe at anterior portion, 5 mm.

Observations.—In general outline this pygidium is somewhat like that of *Dorypyge richthofeni* Dames. It differs in the proportionately broader axis, narrower pleural lobes, and the pair of strong spines at the postero-lateral angle.

Formation and locality.—Middle Cambrian, central portion of Chang Hsia formation, in hard, dove-colored limestone; 2 miles south of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus DORYPYGELLA, new genus.

This genus is founded on the heads and pygidia of a trilobite associated with *Damesella blackwelderi*.

Diagnosis.—Head transversely semicircular, with a truncato-conical glabella, having a postero-lateral lobe in the dorsal furrow and a narrow frontal rim and border, fixed cheeks medium to broad, with relatively large, elevated, palpebral lobes; facial sutures, cutting the anterior rim in front of the anterior base of the eye lobe, extend inward and backward in a slight outward curve to the eye lobe; arching about the eye lobe they extend outward and backward with a sigmoid flexure, cutting the posterior rim within the postero-lateral angle.

Associated pygidia transversely semicircular, axis conical, with two or more rings, marginal border spinose, with the anterior pair of spines, in the type species, very strong.

It may be that some of the pygidia described under *Olenoides* and *Damesella* belong to this genus, but with our present knowledge it would be difficult to identify them.

The genus is characterized by the peculiar glabella, narrow frontal margin, and spinose pygidium. It is assumed that the pygidia associated with the heads belong to the genus, as there is no other associated form to which they could be referred except *Damesella blackwelderi*, and from this the pygidium differs in its short conical axis and the character of the spinose border.

Genotype.—*Doryppygella typicalis.*

The species referred to the genus are: *Doryppygella typicalis* Walcott, *Doryppygella alcon* Walcott, *Doryppygella alastor* Walcott.

DORYPYGELLA TYPICALIS, new species.

Head transversely semicircular, moderately convex. Glabella truncato-conical, with the sides converging gently to the rounded front; three pairs of glabellar furrows are indicated by slight, short depressions at the sides next to the dorsal furrow; back of the posterior pair of depressions a low rounded ridge extends out onto the fixed cheek, forming a low, oval-shaped tubercle or lobe that is apparently the continuation of the postero-lateral lobe of the glabella; a small pit occurs just back of it, from which the occipital furrow starts; the latter is shallow, clearly defined, and extends slightly backward and then forward toward the center; occipital ring of medium width at the sides, broadening out to a somewhat flat, rather strong, segment at the

center; dorsal furrow obscure, and interrupted by the small lobe at the postero-lateral angle of the glabella and by the ocular ridge at its antero-lateral angle.

Fixed cheeks about two-thirds the width of the central portion of the glabella; they rise somewhat rapidly from the dorsal furrow to the palpebral lobe, and slope gently back to the posterior furrow and in front of the ocular ridge rather rapidly to the furrow within the frontal rim; ocular ridges strong and rather prominent; they originate against the antero-lateral angle of the glabella and extend obliquely backward across the fixed cheek and merge into the rim of the palpebral lobe; palpebral lobe elevated above the fixed cheek, prominent, and about one-third the entire length of the head; a shallow groove extends from the thick, strong, broad, elevated rim down to the fixed cheek; postero-lateral limb about as long from the dorsal furrow to its extremity as the length of the glabella and occipital ring; a narrow furrow within the sharp posterior margin gives it an almost concave form; frontal border transverse or slightly incurved; it is elevated, rounded, and separated from the front of the glabella by a narrow sharply defined furrow that extends outward and slightly forward between the rim and the fixed cheeks; it is nearly flat, broad at the center, narrowing toward the facial suture.

The associated free cheek is subrhomboidal in outline, with a narrow rim that is slightly flattened in front, becoming more rounded toward the posterior lateral angle, which has a short, sharp, backward-extending spine; the body of the cheek is slightly convex, rising broadly from the border to the base of the eye lobe; the posterior border is short, being cut a short distance within the postero-lateral angle by the facial suture; facial sutures, cutting the frontal limb, extend directly backward, with a slight outward curve to the eye lobe, around which they curve; back of the eye lobe the sutures continue with a slight sigmoid flexure outward and backward, cutting the posterior margin a short distance within the postero-lateral angle.

The associated pygidium, which is referred to this species, is transversely semicircular, with a short, conical, convex axis. The axis is divided by two narrow, shallow, transverse furrows into two anterior segments and a terminal segment about as long as the two anterior segments. Pleural lobes depressed, nearly flat for a short distance, and then sloping gently down to a narrow, flattened margin; they are marked by three shallow furrows, which separate a strong, anterior, narrow, elevated rim, two slightly convex segments, and a posterior segment at the end of the axis; the furrows and segments stop at the line of the flattened margin, with the exception of the anterior elevated rim, which continues across the margin, and is extended into a strong spine that curves outward and backward; the border is narrow, slightly flattened and transverse, but somewhat incurved posteriorly; it has four or more short, broad, backward-extending spines.

The surface of the central portions of the head is apparently smooth under a strong lens, with the exception of a few scattered, depressed tubercles; the free cheeks have a few irregular, raised, inosculating lines extending from the base of the eye outward toward the rim; the surface of the associated pygidium appears to have a few very minute tubercles that can be seen only with the aid of a strong lens.

Observations.—The transverse front of the head of this species suggests the head of *Conocephalites frequens* Dames, but the glabella is entirely different in form. It differs from *Dorypygella alcon* and *D. alastor* Walcott by the narrower free cheeks and glabella, and the form of the frontal rim.

Formation and locality.—Middle Cambrian. In gray, crystalline limestone; 3.25 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

DORYPYGELLA ALASTOR, new species.

This species is represented by a single specimen of the central portions of a moderately convex head and several associated pygidia that occur at the same horizon as *Dorypygella alcon*.

Head, as indicated by the specimen, transversely semicircular and moderately convex. Glabella broadly truncato-conical, narrowing to the gently rounded front; two pairs of narrow, short furrows extend obliquely inward and backward; the posterior pair outline a rather large postero-lateral lobe, which is confluent with an oval-shaped lobe that interrupts the dorsal furrow and on one side merges into the fixed cheek; a second pair of furrows outlines a small, narrow lobe that is scarcely separated from the fixed cheek by the dorsal furrow; occipital furrow narrow, transverse; occipital ring broken away; dorsal furrow slightly outlined in front and at the anterior lateral angles of the glabella, and practically nonexistent back of that at the sides, owing to interruption by the merging of the lobes of the glabella, and the fixed cheeks.

Fixed cheeks nearly as wide as the anterior portion of the glabella, interrupted by strong, low, ocular ridges that originate at the anterior lateral angle of the glabella and extend obliquely outward and backward to the palpebral lobe; palpebral lobes large, about one-half the length of the head, and rising abruptly from the nearly flat, fixed cheek; their outer margin is broad, rounded, elevated, semicircular, with a deep groove sloping down to the fixed cheek; frontal limb very narrow, merely a rounded ridge between the glabella and the flat frontal rim; to the sides it merges into the strong ocular ridge and downward slope of the fixed cheek in front of the ridge; frontal rim narrow, nearly flat, and rising to the slightly rounded margin.

Surface apparently smooth with the exception of a few small, scattered pustules on the glabella.

At this same locality and horizon, and in limestone of the same character but not in the same hand specimen, there is a number of pygidia which appear to possess characteristics distinct from those of any described species, and which have been referred to *D. alastor*. They are of the same type as those that have been referred to *D. typicalis*. They are transversely semicircular in form, exclusive of the spines on the border. Axis elongate conical, convex, divided by five shallow furrows into five transverse, very slightly convex rings, and a terminal section a little longer than the greatest width of any ring; the terminal section ends somewhat abruptly and slopes rapidly downward to the margin; it is marked at the point where it slopes downward by a small node each side of the center. Dorsal furrow very slight, as the pleural lobes are nearly flat but slightly convex before reaching the margin; the pleural lobes are divided by five shallow furrows into a narrow frontal rim or segment and a posterior obscure segment; the furrows and segments, with the exception of the anterior furrow and segment, terminate at the inner margin of the border; the anterior furrow crosses the border, and the anterior segment is continued out across the border, merging into the anterior spine. Border flat, distinctly defined except opposite the anterior segment, and bordered with a series of marginal spines; these include a long anterior spine, which is a continuation of the anterior margin and a part of the first segment; back of this there are four pairs of short spines which may be considered in a general way as opposite the four anterior segments; the sixth pair of spines project backward; they are long, broad, flat, and opposite the obscure terminal segment of the pleural lobe; between the two large spines, opposite the dorsal furrow at the side of the axis, are two short spines; all of the spines are more or less flat and merge directly into the flat border with the exception of the two anterior, which are connected with the anterior segment and frontal rim.

The surface of the rings and segments is marked by minute granules; otherwise it appears to be smooth under a strong lens.

A specimen 7 mm. in length has a width of 12 mm., exclusive of the spines; axis 3 mm. in width in front, 1.75 mm. at the posterior end; pleural lobe back of the first segment 3 mm. in width.

This species is characterized by the absence of a frontal limb on the head, and the pygidium differs from that of *Doryppygella typicalis* in having a narrow axis, broad, flat margin, and in the arrangement of the spines of the border.

Formation and locality.—Middle Cambrian, central portion of Chang Hsia formation, in hard, gray, fine-grained limestone; 3.25 miles southwest of Yen Chuang, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

DORYPYGELLA ALCON, new species.

This species is represented by a single, somewhat imperfect specimen of the central portions of the head.

Glabella broadly truncato-conical, its width at the base and its length being the same; a pair of short, shallow, posterior furrows occur, which outline a postero-lateral lobe that extends out into and crosses the dorsal furrow; a second pair of furrows is very slightly indicated a short distance in advance of the posterior pair; back of the postero-lateral lobe there is a deep, sharp, narrow furrow on the slope into the occipital furrow; occipital furrow strongly defined, shallow near the center, and deeper laterally; occipital ring unknown; dorsal furrow well defined at the sides in front of the postero-lateral lobe.

Fixed cheeks about as broad as the glabella; they rise rather rapidly from the dorsal furrow to a height slightly greater than that of the glabella, and slope gently backward to the posterior furrow and rather abruptly downward in front of the ocular ridges; ocular ridges broad and rounded; they originate opposite the glabella, somewhat interrupt the dorsal furrow, and extend outward subparallel to the frontal margin of the head to the palpebral lobe; palpebral lobes broken away, but from the configuration of the broken part of the fixed cheek they appear to have been nearly one-half the length of the head and placed on the most elevated portion of the cheek; frontal rim narrow and nearly flat, transverse, and sloping upward from in front of the glabella and the fixed cheeks.

One of the peculiarities of this head is the blending of the ocular ridge and the downward slope of the fixed cheek, so that it appears to be a strong ridge just back of the frontal rim; another peculiarity is the interruption of the dorsal furrow by the ocular ridges and the postero-lateral lobes of the glabella.

The inner surface of the crust is minutely punctate, as shown by the minute papillæ on the cast; this may indicate that the outer surface was finely granulose.

Length of the head, exclusive of the occipital ring, of the type and only specimen, is 6 mm., with a width near the edge of the palpebral lobes of 10 mm.

This species is distinguished from *D. typicalis* by its broader glabella and fixed cheeks and upward sloping frontal rim, and from *D. alastor* by the absence of a frontal limb and the character of the lobes of the glabella. The pygidia, which are referred to *D. alastor*, may possibly belong to *D. alcon*; but from the fact that they are evidently from a different bed of limestone, and that there are no specimens of the head associated with the pygidia, I do not think it best to include them under this species, especially as the head of *D. alastor* and the pygidia appear to be from the same bed of limestone.

Formation and locality.—Middle Cambrian, central portion of Chang Hsia formation, in hard, gray, fine-grained limestone; 3.25 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus DAMESELLA, new genus.

Diagnosis.—General form elongate, ovate, distinctly trilobate, moderately convex. Head transversely semicircular, with the postero-lateral angles rounded or spiniferous; the anterior and lateral margins have a thickened or elevated border, within which there is a well-marked furrow. Glabella truncato-conical, marked with two or more pairs of short furrows; occipital furrow strongly defined; occipital ring rounded. Fixed cheeks rather broad. Free cheeks subtriangular in outline, rising with a gentle curvature to the base of the eye lobe; the border is extended into a lateral spine a short distance in advance of where it is cut by the facial suture. Facial suture, cutting the anterior border nearly opposite the base of the inner margin of the palpebral lobe, extends with slight curvature backward to the palpebral lobe; curving about the latter it extends outward and backward, cutting the posterior margin a little in front of the rounded postero-lateral angle. Eyes small, elevated, and situated about midway of the glabella.

Hypostoma sub-rhomboidal in outline; central portion strongly convex, elevated, with an irregular border at the back and sides, broadening out in front to a greater width than at the back.

Thorax with twelve or more transverse segments; axis about one-third the width of the thorax, gradually narrowing posteriorly. Pleuræ nearly horizontal, at right angles to the axis out to the point where they cuvre gently backward before terminating in a falcate extremity; pleural groove long, deep, and broad, starting at the dorsal furrow near the front and extending out on the falcate end.

Pygidium sub-semicircular; axis convex, broadly conical, and divided into four or more rings by transverse furrows; lateral lobes depressed, convex, and divided by furrows into four or more segments; border rounded, and bearing five or more spines on each side.

Surface in the type species granulose.

This genus differs from *Dorypyge*, with which it appears to be most nearly related, in the character of the head; as far as known the thorax and pygidium are essentially of the same type, as far as fragments of *Dorypyge* can be compared with *Damesella*. The pygidium of *Damesella* is of essentially the same type as that of *Olenoides*, and the pleural lobes of the thoracic segments are also of the same type; but the thorax of *Olenoides* has eight segments and a strong median spine on the axis, while the thorax of *Damesella* has twelve or more seg-

ments and is without a median spine; from what is known of the head of *Olenoides* it is probably the same as that of *Doryppyge*.

Genotype.—*Damesella blackwelderi* Walcott.

The species referred to the genus are: *Damesella blackwelderi* Walcott, *D. bellagranulata* Walcott, *D. brevicaudata* Walcott, *D. chione* Walcott, *D. sinensis* Bergeron = *Dicellocephalus? sinensis* Bergeron.

The genus *Dinesus* Etheridge, jr.,[a] appears to be more nearly related to *Doryppyge* Dames than to *Damesella* or *Doryppygella* Walcott. Its marked characteristics are: the elongate oval glabella, with the small, distinct antero-lateral and postero-lateral lobes; the small palpebral lobes; and the large pygidium with a spinose border. Only one species is known—*Dinesus ida* Etheridge, jr.

Under the definition of Proparia, Dr. C. E. Beecher gives as an ordinal character "Free cheeks not bearing the genal angles,"[b] and under Opisthoparia he said "Free cheeks generally separate, always bearing the genal angles."[c] In *Damesella* the facial suture cuts the postero-lateral margin outside of the genal angle, so as to leave the genal angle on the fixed cheeks and at the same time the spine corresponding to the genal spine in other genera of the order Proparia on the free cheek. In other characters *Damesella* belongs with the Proparia, and I think that the definitions of the orders Proparia and Opisthoparia need to be modified in relation to the exception made by *Damesella* in the position of the genal angle on the fixed cheek.

DAMESELLA BLACKWELDERI, new species.

General form ovate, moderately convex; distinctly trilobed, the central axis rather strongly convex, and the pleural lobes more or less flattened.

Head transversely semicircular; frontal margin rounded and narrow in young individuals, becoming broader and more flattened with increase in size; it continues around the sides and the postero-lateral angle to unite with the narrowing posterior margin. A postero-lateral spine projects backward and slightly outward from a point on the margin a little in advance of the postero-lateral angle.

Glabella large, truncato-conical in outline, and marked by three pairs of short furrows; the posterior pair of furrows form a rounded pit near the margin and continue obliquely outward as a shallow furrow to the central third of the glabella, separating a short, rounded lobe on each side; the middle pair of furrows are short and very lightly impressed; the anterior pair of furrows are indicated by a short, smooth, narrow space at the anterior fourth of the glabella; occipital furrow of medium width, rounded at the bottom and rather deep; it

[a] Proc. Roy. Soc. Victoria, VIII, n. ser., 1896, p. 56, pl. 1, figs. 1–5.

[b] Am. Jour. Sci., III, 1897, p. 198.

[c] Idem, p. 187.

curves backward slightly at the sides and then arches gently forward at the middle; occipital ring of medium width, curving slightly backward at the ends and forward at the center, rounded on top; dorsal furrow strongly marked all about the glabella, and passing posteriorly into a narrow but well-defined furrow within the posterior margin of the postero-lateral limb; the front of the glabella almost overhangs a strong furrow within the frontal border that separates the frontal border from the fixed cheeks; frontal border or rim strong, rounded, and arching slightly upward in front of the glabella.

Fixed cheeks a little more than one-half the width of the glabella. They slope gently back to the furrow on the postero-lateral limb and rather rapidly downward in front of the palpebral lobe to the furrow within the frontal border. A clearly defined, low, rounded ocular ridge extends opposite the anterior fourth of the glabella to the palpebral lobe, into the rim of which it merges; postero-lateral limb about one and one-third times as long as the width of the glabella at its base, and back of the palpebral lobe about one-third the length of the head; palpebral lobe a little less than one-third the length of the head, elevated at the outer rim, and rather narrow.

The facial sutures cut through the rounded frontal margin of the head obliquely and around backward, passing almost directly to the anterior margin of the palpebral lobe; curving around the rather small eye lobe, they pass obliquely outward and backward, cutting the border of the head a little in advance of the postero-lateral angle.

Free cheeks roughly subtriangular, with the outer margin bordered by a thickened, rounded rim, which gradually increases in width to the base of the long postero-lateral spine. Back of the spine to the facial suture the border narrows rapidly. The body of the cheek rises at a uniform slope to the base of the eye lobe.

Thorax with a convex axis that narrows gradually from the anterior segment, where the width is 15 mm., to the twelfth segment, where it is 12 mm. One specimen preserves twelve segments, with the pygidium, and it may be that other segments are broken off. The segments are nearly transverse, except at the geniculation on the pleural lobes, where the falcate extremities bend slightly backward; pleural lobes flattened three-fourths of the distance out, where they curve slightly downward to the extremities of the pleurae; pleural groove occupying nearly the entire width of the pleura, except near the axis, where it narrows toward the front margin. At the outer extremity it fades out where the pleura curves outward and backward. There is some difference in the strength and width of the pleural groove in different specimens. In some it has practically the same width from the axis out to its extremity, while in others it is narrow toward the axis and not quite as broad through the central portions.

Pygidium large, semicircular; axial lobe divided by four well-

defined transverse furrows, that arch slightly forward, into four moderately convex rings and a somewhat elevated terminal portion which has the appearance of a thickened ring, with a strong node on each side of the center and a slightly defined furrow on its front slope; the terminal ring slopes rapidly downward to the border; lateral lobes broad, slightly convex, and marked by a narrow anterior ring, which joins the thorax, and four strong, rather broad furrows that separate three rings and a broad, obscure terminal ring; two obscure ridges run down the posterior slope of the central axis from the two nodes upon the posterior end of the central axis and terminate in spines on the border; each of the rings of the pleural lobe, including the anterior border, terminates in a long, slender spine, that of the anterior border being much longer than the others; this arrangement gives five spines on each side of the axis and two spines back of the axis; the border is rounded and much interrupted by the strong spines extending out from it.

Surface of the crust minutely punctate under a strong lens, and marked by strong pustules, more or less irregularly arranged on the surface, except in the furrows; on the segments of the thorax the pustules are arranged on the front and back margins of the pleura and on the higher portions of the rings on the axis; on the pygidium the pustules occur on the elevated rings and somewhat irregularly on the pleural lobes, but not on the spines. On some portions of the surface, under a very strong lens, there appears to be an irregular, inosculating, elevated series of lines or striæ interrupting the surface, leaving minute depressions or punctæ between them.

The portion of the thorax preserving twelve segments has a length of 50 mm., with a width at the anterior end of the axis of 16 mm., and on the pleural lobes of 24 mm.; the head of this specimen has a length of 26 mm. and a width of 64 mm., exclusive of the postero-lateral spines.

Observations.—The pygidium of this species is not unlike that of *Olenoides leblanci* Bergeron,[a] from China, but it differs in the more depressed axis and in the character of the spines on the border. This conclusion is given after an examination of the figures of M. Bergeron and a comparison of specimens which have been identified as *Olenoides leblanci* from the Ku San shale formation, 2.5 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China, which appears to be the horizon from which the various species described by M. Bergeron were obtained. From *Olenoides marcoui* the pygidium of *Damesella blackwelderi* differs in the same manner as from *O. leblanci*. From *Dorypyge slatskowskii* Fr. Schmidt,[b] it differs in the character of the head and the general shape of the pygidium and its spinose border. From

[a] Bull. Soc. Géol. de France, 3d ser., XXVII, 1899, p. 46.

[b] Mém. Acad. Imp. Sci. St.-Pétersbourg, 8th ser., VIII, No. 10, p. 33, pl. II, figs. 1–10.

Olenoides dubia and *Dorypygella alastor* it differs in the slender axis and spinose border of the pygidium.

This is one of the finest of the trilobites collected by Mr. Blackwelder; and owing to the fact that there is a number of specimens of the head and pygidium, and one specimen preserving the head attached to twelve segments of the thorax, it is possible to separate it from the genera *Dorypyge* and *Olenoides* and to establish a generic type, the specimens of which have hitherto been confused with *Dorypyge*. It is not impossible that an entire specimen of *Olenoides leblanci* would prove that species to belong to the genus *Damesella*.

Formation and locality.—Middle Cambrian; central portion of Chang Hsia formation, in gray limestone, 3.25 miles and 6 miles southwest of Yen Chuang, Hsin Tai. In talus, in dark limestone; 2.8 miles and 6 miles southwest, and 2 miles south of Yen Chuang, Hsin Tai, Shangtung, China.

The stratigraphic range given this species is based upon the comparison of specimens that appear to be identical.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

DAMESELLA BELLAGRANULATA, new species.

This species is represented by the central portions of the head, exclusive of the free cheeks. These parts indicate that the head was transversely semicircular and moderately convex.

Glabella truncato-conical, moderately convex, and marked by two pairs of very faintly indicated short furrows; occipital furrow narrow, transverse, clearly defined; occipital ring of moderate width and slightly convex; dorsal furrow clearly defined on the sides of the glabella; frontal border narrow, rounded.

Fixed cheeks of nearly the same width as the glabella opposite the palpebral lobes; they slope up very slightly from the dorsal furrow to the palpebral lobe, and gently backward to the slight furrow within the posterior margin; to the front they curve down rather rapidly to the frontal border; ocular ridge narrow and faintly defined; palpebral lobe a little more than one-fourth the length of the head, rising somewhat abruptly from the plane of the fixed cheeks; postero-lateral limb from the dorsal furrow to its extremity about the same length as the width of the glabella at its base; it is marked by a shallow, narrow furrow some distance within the posterior margin.

The surface is ornamented by rather large, closely arranged pustules that cover the glabella and fixed cheeks; the pustules are larger on the occipital segment and its extension on the postero-lateral limbs and on the frontal border; larger pustules are also scattered on the back portion of the head near the dorsal furrow. Over the spaces between the larger pustules and on the pustules there is a minute

granulation that gives a very highly ornamented surface under a strong lens.

The type and only specimen of the head in the collection has a length of 12 mm., of which the glabella occupies 9 mm.; the width at the outside of the palpebral lobes is 17 mm., and at the ocular ridges 5.5 mm.

The head of this species is much like that of *Damesella blackwelderi* in general form, but it differs in the elevated eye lobes and the peculiarly ornamented pustulose surface.

Formation and locality.—Middle Cambrian, central portion of Chang Hsia formation, in a gray slabby limestone; 6 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

DAMESELLA BREVICAUDATA, new species.

This species is based upon a pygidium that is transversely semicircular in shape, with a short, strong, convex axis. The axis is marked by two anterior transverse furrows and a very shallow posterior furrow, that divide the axis into an anterior ring, that joined the thorax, two faintly defined rings, and a rounded terminal section; the axis rounds down abruptly at its broad posterior end, passing into the margin.

The dorsal furrow is narrow and clearly defined on each side of the axis.

Pleural lobes flat for a very short distance, and then rounding downward to the border; each lobe is marked by an anterior, deep, narrow furrow within the margin, and four strong furrows terminate within the border; they divide the lobes into four elevated segments that merge into the irregular border; from the border fourteen spines project; the anterior spines appear to be the continuation of the anterior elevated margin of the pygidium and the first segment; the second, third, fourth, and fifth spines are opposite the furrows between the segments, and do not appear to be the direct continuation of the segments, although a low ridge from each segment crosses the margin obliquely to them; two spines project back of the axis, and one on each side opposite the dorsal furrow on the side of the axis.

Surface marked by an irregular row of rather large tubercles on the rings of the axis and anchylosed segments of the pleural lobes; under a very strong lens the surface appears to be slightly roughened or minutely punctate.

Dimensions.—Length, 7 mm.; width in front of border, exclusive of spines, 16 mm.; width of axis at anterior margin, 5 mm.

Observations.—This species is characterized by its short, wide, convex, central axis, relatively narrow pleural lobes, and very strong spinose border. It differs from *Dorypyge richthofeni* Dames in its

short, broad axis and the character of the pleural lobes and spinose border.

Formation and locality.—Middle Cambrian; upper portion of Chang Hsia formation, in hard gray limestone; Chang Hsia, Shangtung, China.

DAMESELLA CHIONE, new species.

Of this species there are several well-preserved central portions of the head, free cheeks, and pygidia.

The head is transversely semicircular, moderately convex. Glabella convex, truncato-conical, rounded in front; the length is slightly greater than the width at the base; a posterior pair of glabellar furrows extends inward and obliquely backward a short distance, so as to outline a small, oval, slightly convex lobe at the postero-lateral angles, a second pair of very slightly impressed short glabellar furrows occurs about one-half way between the posterior furrows and the front; occipital furrow narrow, transverse, clearly defined; occipital ring narrow at the sides, increasing in width toward the center, slightly convex and a little elevated at the back; dorsal furrow narrow and distinct.

Fixed cheeks about one-half the width of the glabella at the base and moderately convex; they round up from the dorsal furrow and are nearly flat out to the palpebral lobe, back of the line of which they slope gently to the furrow of the postero-lateral limb and in front more abruptly to the furrow within the front margin; palpebral lobe a little more than one-third the length of the head, narrow, distinct, but not rising above the general level of the fixed cheek; ocular ridge indicated only by a very narrow, smooth line between the anterior end of the palpebral lobe and the dorsal furrow; postero-lateral limb narrow, and extending out a considerable distance to a rather blunt, rounded end; front margin of the head badly preserved; it appears to have been short, rounded, and separated from the glabella and fixed cheeks by a narrow furrow.

Free cheeks subtriangular in outline, with a distinct, narrow, slightly elevated border and a sharp postero-lateral spine; from the base of the spine an inner flattened border originates and narrows to a point below the front of the eye lobe; it is defined by a narrow furrow within the sharp rim and the furrow between it and the central portion of the cheek; it is marked by granules in the same manner as the body of the cheek; the narrowing and disappearance of the flat border, leaving only the narrow rim at the facial suture, indicates that the border in front of the fixed cheeks of the glabella was very narrow; body of the cheek moderately convex, rounding up from the furrow at its base to the base of the strong eye lobe; the facial suture extends with a slightly sigmoid curve from the posterior base of the eye lobe outward and backward to the furrow within the rather broad posterior margin of

the free cheek; it there cuts directly across the lobe, leaving a short portion of the broad margin extending obliquely forward and outward to the base of the postero-lateral spine; in front of the palpebral lobe the facial suture extends forward and slightly outward to the front margin.

There are several specimens of an hypostoma associated with the species that appear to belong to it. The central portion is convex, subovate, and crossed toward the front by a strong furrow subparallel to the rounded front margin; a narrow rim surrounds the front and expands into two ear-like flattened projections opposite the strong furrow crossing the central portion; the margin then contracts so as to leave a narrow, rounded rim opposite the convex portion of the posterior part of the central body; it then expands so as to form a subtriangular limb on each side at the postero-lateral angles of the hypostoma. This hypostoma is of the same type as that of *Damesella blackwelderi*.

The associated pygidium is transversely semicircular, with a spinose margin and convex conical axis. The axis is divided into five rings and a subtriangular terminal portion by five transverse furrows; the two anterior rings are rather convex, while the three posterior are but slightly defined by shallow, narrow, transverse furrows. The pleural lobes are slightly convex out to the geniculation, where the slope is somewhat abruptly downward to the end of the falcate termination of the segment outlined on the lobe; the furrows crossing the axis extend out on the pleural lobes, so as to define a narrow anterior segment and four posterior segments and a central portion extending down from the axis; each of the segments terminates in a falcate, backward-curving, short, flat spine, of which there are six on each side, one for each of the segments and two back of the axis; there does not appear to be any clear indication of a border, as the space is occupied entirely by the segments and their falcate ends.

The surface of the glabella, fixed cheeks, free cheeks, and occipital ring is marked by numerous, rather closely set, depressed pustules, between and on which there are very fine punctæ, as determined by a strong lens. The surface of the pygidium is marked by strong pustules or granules that are thickly set on the segments but not on the furrows. There appears to be considerable difference in the strength and size of the granules on different specimens. This may be simply a matter of the state of preservation, or the amount of wear to which the crust has been subjected, or it may indicate a variety or even a different species.

A head 3 mm. in length has a width of 5 mm. at the exterior of the palpebral lobes, and a width at the base of the glabella of 2 mm.

Observations.—The pygidium illustrated by M. Bergeron and named *Dicellocephalus ? sinensis*,[a] which occurs at this same stratigraphic

[a] Bull. Soc. Géol. de France, 3d ser., XXVII, 1899, p. 48.

horizon in China appears to resemble more closely than any other form the pygidium of this species. As illustrated and described by M. Bergeron it differs from *Damesella chione* in its shorter axis, five instead of six spines on the margin, and a smooth instead of granulose surface. *Damesella chione* has a head of essentially the same type as that of *D. blackwelderi;* but the pygidium differs in having its anchylosed segments extending out directly across the border into the falcate spinose ends, instead of stopping within the border and having spines representing the extension of the segments extending outward from the border.

Specimens of *Drepanura* Bergeron and *Agnostus douvillei* Bergeron are associated with *Damesella chione*, and *Ptychoparia ceus* Walcott and *Shangtungia spinifera* Walcott occur at the same horizon and in many instances on the same hand specimen with *D. chione*.

Formation and locality.—Middle Cambrian, Ku San shale formation; 2.5 miles southwest of Yen Chuang, Hsin Tai, and in isolated hills 12 miles S. 80° E. of Tai An Fu, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus AGRAULOS Corda.

AGRAULOS ABARIS, new species.

Glabella and fixed cheeks convex, subrhomboidal in outline and strongly rounded in front. Glabella moderately convex; sides slightly converging; front broadly rounded; surface marked by three short and very slightly impressed furrows; occipital furrow shallow and arching slightly forward at the center. Occipital ring narrow at the sides, gradually increasing in width to the broad base and a strong occipital spine.

Fixed cheeks slightly convex, about half the width of the glabella; between the glabella and palpebral lobes the cheeks are almost flat; posteriorly they slope rapidly downward to the short postero-lateral limbs; in front they also slope rapidly downward and merge into the frontal limb; palpebral lobes small; ocular ridges narrow and faintly defined; frontal limb slightly prominent at the central portions, where it merges into the rounded frontal rim, the line of demarcation between the two being very slightly defined; at the sides the frontal rim narrows and is elevated above the lateral extension of the frontal limb; dorsal furrows very distinctly defined.

Surface apparently smooth under a strong lens, with the exception of very indistinct irregular lines that radiate from the front of the glabella outward across the frontal limb.

The one specimen of this species in the collection has a length of 5 mm. exclusive of the occipital spine. The width at the palpebral

lobes is 5 mm. This species is clearly separated from other forms by its strongly defined glabella and prominent limb, which is formed by the union of the true limb and the frontal margin.

Formation and locality.—Lower portion of Chang Hsia formation near base of oolitic limestone. Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

AGRAULOS ABROTA, new species.

This species is represented by several small heads exclusive of the fixed cheeks. It is closely related to *Agraulos dryas* but differs from it in the greater width, stronger convexity of the glabella and greater downward slope of the frontal margin. The surface is also more minutely punctate than that of *Agraulos dryas*. Largest specimen is a little less than 3 mm. in length.

Formation and locality.—Middle Cambrian. Lower portion of Chang Hsia limestone. In gray oolitic limestone, Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, Carnegie Institution of Washington Expedition to China.

AGRAULOS ACALLE, new species.

Central portions of head, exclusive of free cheeks, moderately convex. Glabella truncato-conical, convex, short, scarcely more than one-half the length of the head, and without traces of furrows; occipital furrow not much more than a depressed line; occipital ring broad, almost subtriangular in outline, and rising at the center to a small node.

Fixed cheeks about as wide as the glabella, strongly convex, and merging into a frontal limb of about equal width and convexity; palpebral lobe minute, situated opposite the central portions of the glabella; postero-lateral limbs short and marked by a narrow furrow parallel to the margin.

Surface smooth under a strong lens. The heads vary in length from 3 to 4 mm. A specimen 3 mm. in length has a width of 2.5 mm. at the palpebral lobes.

Formation and locality.—Middle Cambrian. In gray crystalline limestone, 3.25 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

AGRAULOS AGENOR, new species.

Glabella slightly truncato-conical, strongly convex; occipital furrow rounded, clearly defined; occipital ring slightly convex, subtriangular in outline, narrow at the sides and broadening out to an obtuse spine behind; dorsal furrow narrow and clearly defined.

Fixed cheeks about one-half the width of the glabella, convex, rising from the dorsal furrow and arching down to a small palpebral lobe; the fixed cheeks slope rapidly backward to a short postero-lateral limb, and anteriorly to a rather broad, very slightly convex frontal limb; a rather deep, narrow furrow occurs within the elevated margin of the postero-lateral limb.

Surface minutely punctate under a strong magnifier, the punctæ formed apparently by an irregular network of elevated lines. The only specimen of the head representing this species has a length of 2.5 mm.

Formation and locality.—Middle Cambrian, Chang Hsia formation, about 50 feet below the Ku San formation, in conglomeratoid limestone. Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

AGRAULOS DIRCE, new species.

This species is represented by the central portions of the head, exclusive of the fixed cheeks. The surface is depressed, convex, with the glabella rising but little above the general surface at the front, and but moderately convex at the base.

Glabella truncato-conical, indistinctly defined from the frontal rim and at its base from the occipital ring; without traces of furrows; occipital furrow indicated only by the very slight convexity of the occipital ring.

Fixed cheeks about three-fourths of the width of the glabella; posteriorly they merge into the short postero-lateral limbs and toward the front into the broad, gently convex, frontal limb, which continues uninterruptedly to the anterior margin of the head; palpebral lobes small; ocular ridges indicated by a dropping down of the fixed cheek at the place where the ridges usually occur.

This species recalls the general form of *Agraulos strenuus* Billings; it differs in being less convex, in its broader fixed cheek and short occipital ring. It also differs in its wider fixed cheeks from *Agraulos dolon*, which occurs at about the same geologic horizon.

The largest head in the collection has a length of 11 mm. and the same width at the palpebral lobes.

Formation and locality.—Middle Cambrian. Lower portion of Chang Hsia formation near base of oolitic limestone; 3 miles north-northeast of Hsin Tai Hsien, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

AGRAULOS DIVI, new species.

This species is represented by portions of the central parts of the head. The glabella is convex, truncato-conical in outline, the width at the base and the length being the same; three pairs of glabellar furrows are very slightly indicated; occipital furrow shallow and broad; occipital ring narrow at the sides, gradually widening toward the center, very slightly convex, and without an occipital spine.

Fixed cheeks about as wide as the front end of the glabella and nearly flat opposite the palpebral lobes; posteriorly they slope slightly into a strong groove parallel to the posterior margin, and in front the slope is slight down to a broad, slightly indicated, transverse furrow.

Palpebral lobes unknown, only a trace of the ocular ridge is shown; frontal limb convex, broad, and extending to the frontal margin without any trace of a line of demarcation between it and the frontal rim; a broad, shallow, transverse furrow extends in front of the glabella and outward across the cheeks below and in front of the ocular ridges; dorsal furrow broad and shallow; surface finely papillose under a strong lens. The largest head of the collection has a length of 9 mm.

This species is characterized by its short glabella, broad dorsal furrow, transverse furrow in front of the glabella, and strong frontal limb.

Formation and locality.—Middle Cambrian. Either base of Chang Hsia formation or in passage beds between the Man To formation and the Chang Hsia formation; 3.2 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

AGRAULOS DOLON, new species.

This species is represented by the central portion of the head, exclusive of the free cheeks. The glabella and fixed cheeks are convex, somewhat rhomboidal in outline; glabella convex, narrowing slightly toward the broadly rounded frontal margin; posteriorly it is separated from the occipital ring by a very faint, narrow furrow; there are no traces of glabellar furrows; occipital ring strong, and merged into the broad, subtriangular base of a strong, short spine; dorsal furrows shallow, but sufficiently strong to mark the line of demarcation between the glabella, fixed cheeks, and frontal limb.

Fixed cheeks a little more than half the width of the glabella, rising rapidly from the facial suture and merging into the frontal limb anteriorly and into the short postero-lateral limbs at the back; palpebral lobes small and narrow; ocular ridges broad but faintly defined; they extend from the antero-lateral angle of the glabella outward and slightly backward to where they unite with the palpebral lobe; frontal limb slightly convex from the front of the glabella to the broadly rounded front margin.

Surface apparently smooth. The largest specimen in the collection has a length of 9 mm., exclusive of the occipital spine.

This species strongly suggests *Agraulos strenuus* Billings from the paradoxides zone of Newfoundland; it differs in the form of the frontal limb and border. In *A. dolon* the frontal limb arches gently downward and forward to the margin, while in *A. strenuus* it is nearly flat and slightly convex between the glabella and the margin. The glabella of the latter is also proportionally longer.

It differs from *Agraulos dirce* in its greater convexity, more clearly defined glabella, and strong occipital spine.

Formation and locality.—Middle Cambrian. Lower portion of Chang Hsia formation near base of oolitic limestone; 2.2 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, Carnegie Institution of Washington Expedition to China.

AGRAULOS DRYAS, new species.

Glabella and fixed cheeks convex; rhomboidal in outline. Glabella convex, short, narrowing slightly toward the rounded front, without traces of furrows; occipital furrow broad, very faintly defined; occipital ring very narrow at the sides, broadening out rapidly to a blunt point so as to be almost triangular.

Fixed cheeks about two-thirds the width of the glabella, and sloping slightly downward to the small palpebral lobes which are situated about midway between the posterior and the front margin of the head; back of the palpebral lobe the fixed cheeks slope rapidly to broad, short, postero-lateral limbs; palpebral lobes short; form unknown; ocular ridges not distinguished on the downward slope of the fixed cheeks toward the frontal limb; frontal limb and frontal rim nearly as long as the glabella; very slightly convex and separated from each other by a shallow, slightly defined depression; dorsal furrow shallow but clearly defined.

Entire surface marked by numerous, rather strong, punctæ; also very fine, almost microscopic, irregular, elevated more or less concentric, striæ on the glabella. Length of head 3.5 mm.

This species is represented by one specimen. It is strongly characterized by its punctate surface and general form.

Formation and locality.—Central portion of Chang Hsia formation, near the top of the oolitic limestone; 1 mile west of Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus ANOMOCARE Angelin.

ANOMOCARE ALCINOE, new species.

This species is represented by a single specimen, preserving the anterior portions of the central part of the head, exclusive of the free cheeks. These parts indicate that the head was large, moderately convex, and longitudinally quadrilateral, exclusive of the free cheeks.

Glabella slightly convex, rising gently from the dorsal furrow toward the center; faint indications of three pairs of glabellar furrows are shown by reflected light over the smooth surface; sides subparallel to the rather broadly rounded front; occipital furrow and ring unknown.

Fixed cheeks about one-half the width of the glabella, nearly flat opposite the palpebral lobes, and sloping gently to the frontal limb, into which they merge in front of the palpebral lobe; the ocular ridge, starting just back of the antero-lateral angle of the glabella, extends obliquely out to the narrow palpebral lobe; frontal limb nearly flat; it slopes gently from the glabella and palpebral lobes to a raised line which separates it from the broad, slightly concave frontal rim.

The surface appears to be smooth under a strong lens.

An associated pygidium has a broad planulate margin and convex axis, with slight indications of about six segments. The most nearly related form from China is *A. decelus*. In the latter form the frontal rim is slightly convex, while in *A. alcinoe* it is slightly concave.

Formation and locality.—Middle Cambrian, upper portion of the Chang Hsia formation, in limestone nodules; 3 miles south of Kao Chia Pu, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ANOMOCARE BERGIONI, new species.

Head, exclusive of the free cheeks, longitudinally sub-quadrilateral, convex. Glabella truncato-conical, moderately convex, and marked in the cast by two pairs of glabellar furrows; also a low, rounded, median ridge; sides slightly arched outward opposite the palpebral lobes; front broadly rounded; occipital furrow deep, rounded, and arching forward slightly at the middle; occipital ring narrow and rising at the center to form the base of a rather strong spine; dorsal furrow strong at sides and less so at the front.

Fixed cheeks very narrow, forming little more than a convex ridge between the dorsal furrow and the furrow within the palpebral lobe; they slope rapidly to the front, merging into the frontal limb, and posteriorly downward to a very short postero-lateral limb; palpebral lobes narrow, about one-third the length of the head; ocular ridge low and merging into the rim of the palpebral lobe; frontal limb short and sloping downward to a slightly convex frontal rim that is about twice as wide as the frontal limb in front of the glabella; the line of demarcation between the frontal limb and rim is little more than a change in direction of the slope, the slope of the rim being less.

The outer crust is exfoliated over most of the head. Where preserved, the outer surface is smooth under a strong lens. The length of the head of the type specimen is 12 mm.; the glabella, exclusive of the occipital groove, 6 mm.; frontal limb, 1 mm.; frontal rim, 2 mm.

This species is doubtfully referred to the genus *Anomocare*, as the glabella does not have the parallel sides so characteristic of that genus and the palpebral lobes are rather short. The reference to *Anomocare* is based on the character of the frontal rim, narrow fixed cheeks, and the general configuration of the glabella.

Formation and locality.—Upper Cambrian, Chao Mi Tien formation, in coarse, gray limestone; 9 miles north of Hsin Tai Hsien, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ANOMOCARE BIANOS, new species.

This species is represented by a portion of the glabella and the frontal limb. The glabella appears to have been quadrilateral in outline, broadly rounded in front, and moderately convex. It is marked in the cast of the interior by very slight traces of three pairs of short glabellar furrows and a very slight, narrow, median ridge; dorsal furrow shallow, but well marked; frontal limb nearly flat for a distance of 2 mm. in front of the glabella, where it curves downward at an angle of about 45° for a distance of 3.5 mm. It is quite probable that at the angle between the flat portion and the sloping front there was some indication on the outer crust of a division between the two parts; if so, the shorter inner portion would be the frontal limb, and the sloping outer portion the flat frontal rim. Exterior surface unknown.

This species is very clearly characterized by the form of the frontal limb.

Formation and locality.—Upper Cambrian, upper portion of the Chao Mi Tien formation, in a hard gray limestone; 2.7 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ANOMOCARE BISTON, new species.

This species is represented by some fragments of the central portion of a head. Glabella moderately convex, subquadrilateral in outline, narrowing slightly toward the broadly rounded, almost transverse front; surface marked by three pairs of slightly impressed short furrows; occipital furrow rounded, distinctly marked, transverse; occipital ring narrow at the sides, broadening toward the center to form the base of a moderately strong spine; dorsal furrow narrow, rounded, and distinct.

Fixed cheeks narrow, scarcely more than a ridge between the dorsal furrow and the palpebral lobe; palpebral lobe about one-third the length of the head, separated from the fixed cheek by a narrow, deep groove; ocular ridge short, distinct, and merging into the rim of the palpebral lobe; postero-lateral limb about as long as the width of the glabella, narrow, and marked by a longitudinal groove. In front of the glabella a narrow frontal limb slopes downward to a slightly convex, flattened frontal rim about three times as long as the frontal limb.

Surface minutely punctate. Length of the largest head, exclusive of the occipital spine, 8 mm.

This little species appears to be quite distinct from any other form of the genus. Its narrow fixed cheeks, relatively large eye lobe, and flattened frontal rim are the characteristics upon which it is referred to *Anomocare*.

Formation and locality.—Middle Cambrian, in the lower half of the Chang Hsia formation, in a compact gray limestone; 2 miles south of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ANOMOCARE (?) BUTES, new species.

General form of head semicircular, moderately convex. Glabella sub-quadrilateral in outline, narrowing slightly toward the nearly transverse front; marked by three pairs of slightly impressed short furrows and a low, narrow, median ridge; occipital furrow shallow, rounded, and arching very slightly toward the center; occipital ring slightly convex and of moderate width throughout, marked by a minute pointed node at the center; dorsal furrow rounded, distinct.

Fixed cheeks less than one-half the width of the glabella; they rise with a gentle slope from the dorsal furrow to the furrow within the rim of the palpebral lobe, slope back into the postero-lateral limb, and somewhat abruptly downward in front of the ocular ridge into the frontal limb; ocular ridge clearly defined and merging into the rim of the palpebral lobe; the latter is a little more than one-third the length of the head; postero-lateral limb nearly as long as the width of the

glabella at the base, narrow, and marked by a strong groove within the rounded posterior margin; frontal limb slightly convex and curving downward to the flattened frontal rim; the rim is a little longer than the length of the limb in front of the glabella, and the line of demarcation between the limb and the rim is little more than the angle formed by the union of the nearly flat rim with the inclined frontal limb.

Free cheeks irregularly triangular; marginal border flattened, strong, and produced behind into a strong, flattened spine; central area slightly convex, and rising rather abruptly to the base of the eye lobe; anteriorly the border of the cheeks narrows to a slender point.

Thorax unknown.

Associated pygidium semicircular in outline, convex; axis convex, about two-thirds the length of the pygidium, and divided by four furrows into four rings and a terminal, longer ring, upon which a slight depression on each side indicates a fifth furrow; the pleural lobes extend out about one-half of the distance nearly flat, and then curve somewhat abruptly downward to a rather broad, flattened margin, into which they merge; the four grooves on the axis and the fifth groove just within the interior margin extend across the pleural lobes, dying out on the flattened margin. Two small nodes occur at the posterior end of the axis, through which a low, broad, rounded ridge extends backward and downward into the flattened margin.

Surface minutely punctate under a strong lens; fine, radiating, irregular, elevated lines cross the frontal limb from the furrow in front of the glabella and the ocular ridge to the flattened frontal rim, and also from the base of the eye lobe to the margin of the free cheeks.

This species varies from the described forms in the broad, relatively short glabella and the configuration of the frontal rim and limb.

Formation and locality.—Middle Cambrian, lower portion of Chang Hsia formation, in a gray, fossiliferous limestone; 3.2 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ANOMOCARE ? DAULIS, new species.

Of this species the central portions of the head, exclusive of the free cheeks and associated pygidium, are known. Glabella rather strongly convex and faintly marked by three pairs of furrows; it narrows slightly toward the rounded front; occipital furrow narrow and curving slightly forward at the center; occipital ring of medium and nearly uniform width from side to side; dorsal furrow shallow and rounded; posteriorly the latter separates a narrow, elongated lobe from the side of the glabella, and joins the occipital furrow; the narrow lobe mentioned extends backward to the occipital furrow and

laterally merges into the fixed cheek; from another point of view the dorsal furrow might be considered to pass outside of the narrow, elongate lobe, near the base of the glabella, and the furrow between the glabella and the elongate lobe would then be an inner division of the dorsal furrow. The surface of the glabella is somewhat irregular on account of the lateral furrows, and a rather rounded, broad longitudinal ridge which extends its entire length.

Fixed cheeks less than half the width of the glabella; they rise from the dorsal furrow and merge into the large eye lobe, and anteriorly are divided by the strong ocular ridge which passes into the strong palpebral lobe; in front of the ocular ridge the cheeks slope downward to a second ridge which extends from the front line of the glabella sub-parallel to the ocular ridge as far as the facial sutures; frontal limb relatively long, slightly concave to the narrow, very slightly rounded rim; postero-lateral limbs short and marked by a strong curve within the narrow posterior rim.

Surface smooth under a strong lens.

The associated pygidium has a strong central axis marked by five or six rings that are very distinct on the broad plannlate margins. This species is strongly characterized by its peculiar glabella with the elongate, narrow lobes near its base; also by the broad, slightly convex frontal rim.

Formation and locality.—Middle Cambrian. Upper part of Chang Hsia limestone, Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ANOMOCARE DAUNUS, new species.

This species is represented by a portion of the glabella and frontal limb, and a fragment of a large, free cheek associated with it; also an associated pygidium which has the same characteristic surface marking.

Glabella slightly convex and marked by three pairs of very faintly indicated furrows; it has a length of 16 mm. with a width of 12 mm. near the base; it narrows slightly toward the rounded front; a fragment of the fixed cheek indicates that the latter was nearly flat between the glabella and palpebral lobe; the frontal lobe is nearly flat for a distance of 4 mm., when it slopes downward to the thickened frontal rim, no line of demarcation distinguishing the frontal rim.

The free cheek indicates a moderate convexity for the head; also that the margin, which is very narrow at the front, widens out gradually toward the postero-lateral angle of the head; the base of the eye lobe shows that the palpebral lobe and eye were relatively small; the line of facial suture, as shown by the free cheek, shows that the postero-lateral limb of the fixed cheek was large and more than half the width of the cheek; also that the antero-lateral limb was strong.

The surface of the glabella is marked by shallow pits varying greatly in size and form; the pits are so closely crowded that the lines of demarcation between them in places form an irregular network; on the posterior portions of the glabella, also on the frontal limb, the shallow pits are more or less scattered, giving a somewhat coarsely punctate appearance; the fixed cheeks and free cheeks are marked by strong, but not large, pits or punctæ, scattered somewhat thickly over the surface; the surface of the associated pygidium is much like that of the cheeks.

The associated pygidium has a width of 26 mm. and a length of 12 mm.; it is moderately convex with a prominent axial lobe and a broad, slightly concave border that merges above the slightly convex pleural lobes. Axial lobe convex with the elevated portion about five-sixths of the length of the glabella; it slopes abruptly downward and backward from the elevated portion to a low slightly convex termination near the posterior margin; divided by five well-marked transverse furrows that separate it into five segments and an obtuse terminal segment which has two rather large, rounded nodes, outlined by a slight depression at the center; the pleural lobes are grooved by the extension of the furrows crossing the axis; also by pleural grooves, both of which extend outward across the pleural lobe and curve backward across the broad, planulate border of the margin.

Formation and locality.—Middle Cambrian. Lower portion of Chang Hsia limestone, in green nodular shales of the horizon of the oolitic limestone at the base of the Chang Hsia formation; 2 miles south of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ANOMOCARE DECELUS, new species.

Of this species only the anterior central portions of the head are known. It is characterized by a broad, nearly flat, frontal rim that, with the frontal limb in front of the glabella, has a slightly convex slope interrupted only by a shallow, narrow groove; the frontal limb is ornamented with raised, narrow, irregular, more or less inosculating lines that radiate from the front of the glabella and ocular ridges down to the narrow groove separating the limb from the frontal margin.

The fixed cheeks are about half the width of the glabella. They are nearly flat and interrupted by a rather strong ocular ridge. The glabella is large, broadly rounded in front, with the sides sub-parallel from opposite the center of the palpebral lobes to the broadly rounded front. The palpebral lobes and posterior portions of the head are broken away in the only specimen known.

This species is associated with *Anomocare minus* Dames, from which it differs in the character of the frontal limb and margin, in which respects it also differs from *Anomocare temenus* and *Anomocare tatian*. It may also be compared with the form from the St. Croix sandstones of Wisconsin, illustrated by James Hall as *Conocephalites diadematus*,[a] and with *A. aleinoe*, from which it differs in having a convex frontal rim instead of concave.

Formation and locality.—Middle Cambrian. Reddish limestone near base of Chang Hsia formation in oolitic limestone. Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ANOMOCARE TATIAN, new species.

This species is most closely related to *Anomocare temenus*. It differs from it in having a proportionately more convex and broader glabella and stronger dorsal furrows. The associated pygidium is also longer in proportion to its width, and it has eight or nine segments in its axis.

The largest head has a length of 13 mm. exclusive of the frontal rim, which is somewhat broken. This probably had a width of about 2 mm. A glabella 10 mm. in length has a width of 8.5 mm. at the base and 7 mm. at the broadly rounded front.

Formation and locality.—Middle Cambrian. Near base of Chang Hsia formation in gray oolitic series. Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ANOMOCARE TEMENUS, new species.

Head large, moderately convex, and transversely quadrilateral, exclusive of the free cheeks. Glabella slightly convex, rising gently from the dorsal furrow to the center, which is marked by a narrow, longitudinal ridge. A glabella 14 mm. in length has a width of 10½ mm. at the base and 8 mm. at the rounded frontal margin; indications of three pairs of glabellar furrows are shown by reflected light over the smooth surface; occipital furrow very shallow, scarcely more than indicating the line of demarcation between the glabella and the rather narrow occipital ring; dorsal furrows shallow.

Fixed cheeks narrow and nearly flat; they merge laterally into the large palpebral lobe and posteriorly slope down rapidly to the posterior margin; ocular ridges low, rather broad, and clearly marking the division between the central portion of the free cheeks and the rapid slope to the frontal rim; frontal limb in front of the glabella narrower than the frontal rim; it is slightly convex and merges into the narrow

[a] 16th An. Rept. N. Y. State Cab. Nat. Hist., 1863, pl. VII, figs. 36, 37.

furrow between it and the rather broad frontal rim; the latter in a head 21 mm. in length is 3½ mm. long; postero-lateral limbs narrow, with a length about equal to the width of the base of the glabella. A strong furrow divides it about midway, parallel to the posterior margin.

Minute scattered pores are shown on the surface under a strong lens.

The associated pygidium has a broad planulate margin, convex axis, and slight indications of three or four segments.

The most nearly related form from China is *A. planum* Dames. This species differs from the latter in its narrower fixed cheeks and larger glabella.

Formation and locality.—Middle Cambrian. Upper portion of Chang Hsia formation in oolitic limestone, about a mile southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus ANOMOCARELLA, new genus.

Anomocarella is proposed to include three species from the Middle Cambrian of China that differ from Anomocare in the absence of glabellar furrows and the presence of a relatively narrow, flattened frontal rim. The sides of the glabella are parallel, palpebral lobes of medium size, and ocular ridges more or less clearly defined. The associated pygidium has a narrow conical axis, marked by several transverse furrows which extend out on the pleural lobes and more faintly on the sloping rim.

Genotype.—*Anomocarella chinensis.*

Two other species are referred to this genus: *A. albion* and *A. baucis*, the latter with some doubt.

ANOMOCARELLA ALBION, new species.

This species is represented by three more or less imperfect specimens of the head exclusive of the free cheeks. These indicate that the head was of moderate convexity and semicircular in outline.

Glabella moderately convex, with a gentle and nearly uniform curvature from side to side; on one specimen three pairs of glabellar furrows are very faintly indicated; the sides of the glabella arch slightly inward between the base and the rounded front; occipital furrow shallow, rounded, slightly separating from the glabella a very slightly convex occipital ring; dorsal suture narrow, but distinctly marked.

Fixed cheeks a little less than one-half the width of the glabella and nearly flat; they merge into the furrow within the palpebral lobe and

posteriorly slope gently downward to the posterior margin; ocular ridges low, rounded, and merging into the flattened palpebral lobes; in front of the ocular ridges the cheeks are interrupted by an obliquely transverse ridge that extends subparallel to the ocular ridge to the front of the glabella, where it merges into the frontal limb; frontal limb very narrow, sloping rather abruptly downward from the dorsal furrow to a narrow furrow separating it from a broad, slightly downward-sloping, nearly flat, frontal rim; postero-lateral limb short and marked by a shallow furrow parallel to the posterior margin.

Surface minutely punctate under a strong lens. The largest head of this species has a length of 18 mm. with a width at the palpebral lobes of 19 mm.

This large species differs from other forms by the very narrow frontal limb and the flat, downward-sloping frontal rim.

Formation and locality.—Middle Cambrian, lower central portion of Chang Hsia formation, in thin-bedded limestone interbedded with shale; 2 miles south of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ANOMOCARELLA BAUCIS, new species.

This species is represented by a single specimen of about one-half of the head, exclusive of the free cheeks. This specimen indicates a moderately convex head, somewhat longitudinally quadrilateral in outline.

Glabella moderately convex, with the sides converging slightly toward the front; surface apparently free from furrows; occipital furrow broad, shallow, slightly curving forward near the center; occipital ring low, strong, and slightly convex; dorsal furrow shallow, not clearly defined.

Fixed cheeks a little more than one-half the width of the glabella, nearly flat out to the elevated palpebral lobe and sloping with moderate rapidity to the posterior margin. Ocular ridge low, narrow, and merging into the strong palpebral lobe, which is about one-third the length of the head; frontal limb narrow in front of the glabella, widening at the sides in front of the ocular ridges; it slopes gently down to a rounded shallow furrow that separates it from a slightly convex frontal rim, that is broader than the frontal limb in front of the glabella; postero-lateral limb narrow, about as long as the width of the fixed cheek, and marked by a rather strong border and shallow furrow parallel to the border.

Surface marked by scattered punctæ and very fine punctæ visible only with the aid of a strong lens.

This species is characterized by the shallow, rounded dorsal furrow, elevated palpebral lobe, and the smooth, slightly convex frontal rim.

Formation and locality.—Upper Cambrian, upper portion of Chao Mi Tien formation, in grayish-brown, coarse limestone. Chao Mi Tien, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ANOMOCARELLA (?) BURA, new species.

This species is represented by the central portions of a single head. Glabella convex, subquadrilateral, arching very gently from the occipital ring forward, and near the front rather more rapidly downward to the furrow within the frontal rim; without traces of glabellar furrows; occipital furrow narrow, clearly defined; occipital ring rather wide, slightly convex, and projecting a little backward at the center; dorsal furrow shallow, narrow, but clearly defined.

Fixed cheeks about one-fourth the width of the glabella; palpebral lobe more than one-third the length of the head, with a relatively broad outer rim, outlined by a very narrow, faintly defined furrow; ocular ridge short, broad, low, and merging into the palpebral lobe; postero-lateral limb short; frontal rim slightly rounded, separated from the glabella and fixed cheeks by a narrow furrow.

Surface apparently smooth, but with a few scattered, very fine punctæ as seen with a strong lens. The type and only specimen has a length of 3 mm.

The generic reference of this species is doubtful, as the frontal limb is absent. The quadrangular, smooth glabella, relatively large palpebral lobes, and narrow fixed cheeks relate it more closely to *Anomocarella* than to other genera.

Formation and locality.—Middle Cambrian, upper portion of Chang Hsia formation, in oolitic limestone; Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ANOMOCARELLA CARME, new species.

Outline of head, exclusive of free cheeks, elongate quadrilateral, moderately convex. The convexity of the glabella is so slight that it is scarcely raised above the general surface of the head; its outline is truncato-conical, with the front rounded; the interior cast appears to be without traces of furrows; occipital furrow transverse, narrow, rounded, and shallow; occipital ring of medium width, slightly convex; dorsal furrow lightly impressed on the sides of the glabella and scarcely perceptible in front of it.

Fixed cheeks narrow, scarcely more than a line in front of the palpebral lobes; they widen out slightly in front and merge into the frontal limb, and posteriorly into the postero-lateral limb; postero-lateral limbs narrow, length unknown; frontal limb broad, slightly

convex, sloping obliquely downward and passing into the smooth, nearly flat frontal rim almost without interruption from the very shallow transverse furrow; palpebral lobes small, about one-third the length of the glabella.

The only surface markings are the fine, irregular lines that extend from in front of the glabella outward across the broad frontal limb to the frontal rim. The type and only specimen of the head in the collection has a length of 11.5 mm., with a width at the palpebral lobes of 8 mm; the glabella is 6 mm. in length, the frontal limb 2 mm., frontal rim 1.5 mm., and occipital ring and furrow 2 mm.

This species is somewhat doubtfully referred to *Anomocarella*, as the frontal limb and rim are relatively long. It resembles *Anomocarella chinensis* in the narrow fixed cheeks and the absence of glabellar furrows.

Formation and locality.—Upper Cambrian, lower portion of Chao Mi Tien formation, in gray, crystalline, fossiliferous lime stone; Chao Mi Tien, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ANOMOCARELLA CHINENSIS, new species.

Head of medium size, moderately convex, and longitudinally irregularly quadrilateral, exclusive of the free cheeks. Glabella moderately convex, rising gently from the dorsal furrow toward the center, so as to give it a slightly ridged appearance. A glabella 5 mm. in width has a length of 7 mm., exclusive of the occipital ring; surface apparently smooth; occipital furrow very slightly defined; occipital ring broad, very slightly convex, with a slight node a little in advance of the center; dorsal furrow shallow, but distinct on the sides and in front of the glabella.

Fixed cheeks about one-half the width of the glabella, slightly convex; they merge laterally into the furrow outlining the palpebral lobe, and posteriorly slope rapidly to the posterior margin; ocular ridges low, rounded, and passing outward and merging into the narrow palpebral lobe; they clearly mark the division between the central portion of the fixed cheeks and the rapid slope to the frontal rim; palpebral lobes about one-third the length of the head; frontal limb narrow in front of the glabella, widening out at the sides and sloping downward with a gentle convexity; frontal rim nearly flat, separated from the frontal limb by a shallow furrow that curves slightly backward near the center so as to form an obtuse angle. In some examples there is a slight deepening of the furrow on each side of the incurved portion of the frontal rim; postero-lateral limbs short, and marked by a rather shallow, broad furrow parallel to their posterior margin.

Surface minutely punctate under a strong lens. The largest specimen of the head has a length of 12 mm.

The associated pygidium has a narrow, planulate margin and rather narrow convex axis, marked by five transverse furrows, which divide it into five rings, and a small terminal portion; the furrows extend across the pleural lobes and faintly on the margin. The most nearly related form is *A. albion*. The latter differs in having a proportionately shorter frontal limb and rim, and in the form of the glabella.

Formation and locality.—Middle Cambrian, lower central portion of Chang Hsia formation, in limestone interbedded in a green nodular shale; 2 and 2.5 miles south of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus ARIONELLUS Barrande.

ARIONELLUS AGONIUS, new species.

Central portion of the head, exclusive of the free cheeks, irregularly sub-quadrilateral, convex. Glabella moderately convex, narrowing slightly toward the front; length and width at the base nearly the same; by reflected light traces of two pairs of glabella furrows may be seen; occipital furrow narrow and shallow; occipital ring narrow at the sides, becoming stronger toward the center, which rises to form the base of a short, strong, backward-sloping spine; dorsal furrow narrow and clearly defined.

Fixed cheeks narrow and nearly flat at the palpebral lobes; they slope rapidly in front toward the frontal margin, and backward toward the postero-lateral limb; palpebral lobes narrow, about one-third the length of the head; frontal limb narrow directly in front of the glabella and rounding over to the rounded frontal rim.

Surface smooth under a strong lens. The type specimen has a length of 4 mm., with a slightly greater width at the palpebral lobes.

This species differs from *A. alala* in having a thickened, rounded frontal rim and a proportionately wider glabella. From *A. ajax* it differs in being broader and in the presence of an occipital spine.

Formation and locality.—Middle Cambrian, lower-central portion of the Chang Hsia formation, in thin layers of limestone interbedded in the green shale; Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ARIONELLUS AJAX, new species.

Outline of head, exclusive of free cheeks, sub-rhomboidal, convex. Glabella moderately and uniformly convex, sides converging very slightly from the base to the rounded front; slight traces of short

furrows are shown by reflected light; occipital furrow a faint transverse depression that separates the glabella from a fairly strong, slightly convex occipital ring; dorsal furrow narrow but clearly defined.

Fixed cheeks very narrow and sloping away from the glabella toward the palpebral lobes; posteriorly they slope downward into a rather large postero-lateral limb; anteriorly they slope rapidly to the frontal limb; palpebral lobes prominent, about one-fourth the length of the head; frontal limb gently convex, rounded in front, and without traces of a frontal rim.

Surface smooth under a strong lens. The type specimen has a length of 4 mm.

In form the head of this species is somewhat like that of *A. alata*. It differs in the absence of an occipital spine and in being proportionately somewhat narrower.

Formation and locality.—Middle Cambrian, central portion of the Chang Hsia formation, in gray crystalline limestone; 3.25 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ARIONELLUS ALALA, new species.

In general form and proportion the central parts of the head of this species are much like *A. agonius*. They differ in the proportionately smaller, elongate glabella, nearly flat frontal limb, and a thin instead of a rounded margin.

Formation and locality.—Middle Cambrian, central portion of the Chang Hsia formation, in gray limestone; Chao Mi Tien, Shangtung, China.

A somewhat similar and possibly identical form occurs at about the same horizon near Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus MENOCEPHALUS Owen.

Menocephalus OWEN, Geol. Surv. Wisconsin, Iowa, and Minnesota, 1852, p. 577.

Doctor Owen proposed this genus for trilobites having a highly convex, hemispherical glabella, with a narrow border and a broadly rounded front; cheeks tumid.

I have referred to this genus, more or less provisionally, several species in which only the central portions of the head are preserved. Further study, or the study of more perfect specimens, will undoubtedly lead to the reference of some of them to other genera.

MENOCEPHALUS ACERIUS, new species.

This species is represented by a single specimen of the glabella, fixed cheek, and frontal limb. The glabella is moderately convex, broadly truncato-conical in outline, and marked by two pairs of faintly impressed, short furrows; the sides approach each other slightly toward the broadly rounded front; occipital furrow rounded and distinct; occipital ring moderately convex and a little wider than the occipital furrow; dorsal furrow well defined.

Fixed cheeks, convex, about two-thirds the width of the glabella; they slope rather rapidly downward to the frontal rim and less so to the postero-lateral limb; ocular ridge not distinctly defined; palpebral lobes small; frontal rim separated from the glabella and fixed cheeks by a strong, narrow furrow; the rim is rounded and of about the same width as the occipital ring.

Surface covered with pustules perceptible to the unaided eye. The head of the type specimen has a length of 10 mm.; the frontal rim and occipital ring are each about 1 mm. in width.

This species is referred to the genus Menocephalus on account of the small palpebral lobes, pustulose surface, and the absence of a frontal limb. It differs from the type form in having a less convex, more elongated glabella.

Formation and locality.—Middle Cambrian, upper portion of the Chang Hsia formation, in a coarse, grayish limestone; a mile east of Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

MENOCEPHALUS ACIS, new species.

Glabella prominent, convex, narrowing slightly from its base toward the broadly rounded front; occipital furrow narrow, deep, and separating a rather strong, rounded, occipital ring; dorsal furrow narrow and strongly defined.

Fixed cheeks about one-half the width of the glabella, moderately convex to the base of the palpebral lobe; posteriorly they slope rapidly to the furrow within the posterior margin; anteriorly, rapidly to the frontal rim; palpebral lobe small and somewhat elevated; frontal rim narrow, rounded, and separated from the glabella by the narrow dorsal furrow.

Surface marked by rather strong scattered granules. The only specimen representing this species has a length of 5 mm.

This species is characterized by its narrow, wire-like frontal rim and the scattered granules on its outer surface.

Formation and locality.—Upper Cambrian, upper portion of Chang Hsia formation, in granular gray limestone; Chao Mi Tien, Shangtung, China.

Collected by Eliot Blackwelder of the Carnegie Institution of Washington Expedition to China.

MENOCEPHALUS ADMETA, new species.

Glabella strongly convex, with sub-parallel sides and rounded front; occipital furrow narrow and deep; occipital ring narrow at sides, increasing in width toward the center, slightly convex, rising with a backward slope from the bottom of the occipital groove; dorsal furrow narrow and strongly defined.

Fixed cheeks about two-thirds of the width of the glabella, slightly convex opposite the palpebral lobe, and sloping downward to a strong furrow within the rounded rim of the short postero-lateral limb; frontal rim narrow and slightly rounded.

Surface apparently minutely punctate under a strong lens. The only head of this species in the collection has a length of less than 2 mm.

This species is distinguished from *M. acis* by the form of the convex glabella, flattened instead of wire-like frontal rim, and punctate surface. It does not appear to be closely related to any other species.

Formation and locality.—Upper portion of Chang Hsia formation, in dense mottled and crystalline limestone. Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

MENOCEPHALUS ADRASTIA, new species.

This is a minute head, having a strongly convex, almost globular glabella that rises abruptly from the deep dorsal furrow. A shallow furrow outlines small postero-lateral lobes at the base of the glabella; occipital furrow narrow and distinct; occipital ring slightly convex back of the occipital furrow, narrow at the sides and widening gradually toward the center.

Fixed cheeks about one-half the width of the glabella, strongly convex; frontal limb obsolete; frontal rim about half as wide as the fixed cheeks, slightly convex, and separated from the fixed cheeks by a transverse, narrow, shallow groove.

The above is all that is known of this form. Its globose glabella, convex fixed cheeks, and occipital ring distingnish it from other species. The length of the glabella and frontal rim is 2.5 mm. in one specimen, with an occipital ring about 1 mm. long.

Surface finely granulose under a strong lens, with a few scattered larger granules.

Formation and locality.—Middle Cambrian, upper portion of the Chang Hsia formation, in a compact, hard, dove-colored limestone; Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

MENOCEPHALUS AGAVE, new species.

Another species of Monocephalus is associated with *M. adrastia*, in which only the anterior portions of the head and one fixed cheek are preserved. This differs from *M. adrastia* in the proportionately narrower glabella, rounded frontal rim, and less convex fixed cheek. Its surface is very finely pustulose, with scattered larger pustules on the glabella. The palpebral lobe is very small and situated a little back of the center of the head.

Formation and locality.—Middle Cambrian, upper portion of the Chang Hsia formation, in a compact, hard, dove-colored bed; Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

MENOCEPHALUS BELENUS, new species.

This species is represented by a single specimen of a glabella, occipital ring, and frontal rim. It differs from *M. acerius* in having a very narrow, slightly flattened frontal rim, and a very finely pustulose surface. The glabella is also more conical and its front more rounded. A fragment of the fixed cheeks indicates that they were rather convex and rose somewhat abruptly from a distinct dorsal furrow. The general remarks relating to the generic relations of *M. acerius* also apply to *M. belenus*, as they are apparently congeneric.

Formation and locality.—Middle Cambrian, upper portion of the Chang Hsia formation, in a bed above that containing *M. acerius;* Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

MENOCEPHALUS (?) DEPRESSUS, new species.

General form of the head, exclusive of the free cheeks, subrhomboidal, moderately convex. Glabella moderately convex, narrowing slightly from the base toward the rather broadly rounded front; surface marked by two pairs of very shallow, short glabellar furrows; occipital furrow narrow, transverse, and sharply impressed; occipital ring slightly convex and of nearly uniform width; dorsal furrow narrow and sharply defined.

Fixed cheeks about one-half the width of the glabella, convex, arching with about the same slope to the palpebral lobe from the front and back; palpebral lobe small, situated about midway of the cheek; no evidence of the presence of an ocular ridge; postero-lateral limb short, marked by a distinct groove parallel to the narrow, elevated posterior margin; frontal rim narrow, convex, and separated from the glabella and fixed cheeks by a distinct narrow groove.

Surface with numerous low, medium-sized, scattered pustules. The type and only specimen of the head in the collection has a length of 4.5 mm.

This species is doubtfully referred to the genus *Menocephalus*. It is most nearly related to *M. acis*, but differs in having a less convex glabella and narrower fixed cheeks.

Formation and locality.—Upper Cambrian, lower portion of Chao Mi Tien formation, in a fossiliferous gray limestone, where it is associated with *Solenoplura belus;* Pagoda Hill, a mile west-southwest of Tai An Fu, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

MENOCEPHALUS, species undetermined.

This form is represented by the anterior half of the glabella and fixed cheeks. These parts indicate that the glabella was strongly convex, rounded in front, and marked by two pairs of very slight, short furrows. The fixed cheeks are about two-thirds the width of the glabella and moderately convex; palpebral lobes small and placed about their own length from the frontal rim; frontal rim apparently very narrow, and separated from the glabella and fixed cheeks by a narrow distinct groove. Surface finely pustulose under a strong lens.

Formation and locality.—Middle Cambrian, near upper portion of Chang Hsia formation, in a compact, hard, gray limestone, about 3 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus PAGODIA, new genus.

This genus is proposed to include a few species from the Upper Cambrian zone which do not appear to be closely related to any described genus. Only the central portions of the head are available for description.

Diagnosis.—Glabella oblong, with obscure traces of furrows at the sides. Eyes small, central, and without trace of ocular ridge. Facial sutures cut the front margin opposite the eye lobe, and the posterior margin within the postero-lateral angles.

Thorax unknown.

An associated pygidium has a conical, segmented axis, narrow pleural lobes, and smooth, undefined margin.

Genotype.—*Pagodia lotos* Walcott.

The four species of this genus all have a similar type of surface, consisting of shallow punctæ of moderate size, with very fine punctæ, visible only under a strong lens, between the larger punctæ. The species now referred to the genus are *Pagodia bia* Walcott, *P. dolon* Walcott, *P. lotos* Walcott, *P. macedo* Walcott.

I was at first inclined to refer these forms to *Dolichometopus*, but they differ from the type of the latter, *Dolichometopus sprecicus* Anglin, in the narrowing instead of widening of the glabella in front, in the presence of small instead of large eye lobes, short instead of long postero-lateral limbs, and obscure glabellar furrows.

PAGODIA LOTOS, new species.

Glabella moderately convex, elongate, with the sides converging very slightly toward the broadly rounded front; obscure traces of two pairs of furrows that extend a short distance inward and backward occur upon the sides; occipital furrow strong, rounded, and arching slightly forward at the center; occipital ring of medium width and rounded; dorsal furrow strong but shallow and merging into the transverse furrow in front of the glabella.

Fixed cheeks about one-half the width of the head opposite the palpebral lobes, slightly convex, and sloping gently posteriorly to the furrow within the margin and anteriorly to the transverse furrow within the frontal rim; palpebral lobes small, short, not much more than one-fifth the length of the head; a very slight trace of an ocular ridge is shown upon the cast of the interior of the crust, but no evidences of it have been seen on the outer surface; frontal rim narrow, rounded so as to give it a thickened appearance, with a slightly flattened slope into the furrow back of it; it is separated from the glabella and fixed cheeks by a sharp furrow that almost cuts back under the front of the glabella.

The crust is thick; it appears to be smooth on the outer surface over the glabella and fixed cheeks, with the exception of scattered, shallow punctæ.

The type specimen has a length of 6 mm., with a width at the palpebral lobes of 8 mm.

The associated pygidium is convex, subsemicircular in outline, and strongly trilobed except at the margin. Axial lobe convex, conical, and divided by three transverse furrows into three rings and a terminal, rounded subtriangular portion. Pleural lobes nearly flat toward the front near the dorsal furrow, and from there curving abruptly downward toward the side and posterior margins; the furrows of the

axis extend about two-thirds of the distance across the pleural lobes and merge with the flat segments between them into the margin; the margin slopes up from the sharp outer edge with a slight concavity where it merges into the pleural lobes and touches the posterior end of the axis.

This species differs from *Pagodia macedo* and *P. dolon* in its frontal rim and the slight convergence of the sides of its glabella toward the front. It is most nearly related to *Pagodia bia*, with which it is associated, but differs from it in its narrower and proportionately longer glabella, the glabella of *P. bia* having a length of 6 mm. with a width at the center of 3 mm., and that of *P. lotos* with a length of 5 mm. has a width at the center of nearly 4 mm.

Formation and locality.—Upper Cambrian, lower portion of Chao Mi Tien formation, in a gray fossiliferous limestone; Pagoda Hill, 1 mile west-southwest of Tai An Fu, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PAGODIA BIA, new species.

Head, exclusive of the free cheeks, subrhomboidal, moderately convex. Glabella slightly convex, subquadrilateral in outline, slightly narrowed along the central portions, and marked by two pairs of short glabellar furrows on the posterior half and a very slight depression indicating a furrow on each side well toward the front; occipital furrow narrow, very clearly defined and arching slightly forward toward the center; occipital ring narrow and rounded; dorsal furrow shallow but distinct.

Fixed cheeks about half as wide as the glabella and sloping gently downward from the dorsal furrow; palpebral lobes small, situated about midway between the front and back margins of the head; no traces of ocular ridges have been observed; postero-lateral limb short, strong, and marked by a rounded furrow within the posterior margin; frontal rim very narrow, rounded, and separated from the glabella and fixed cheeks by a narrow, deep furrow.

Surface marked by a few shallow, scattered punctæ, and under a very strong lens it appears to be minutely punctate. The largest specimen of the head in the collection has a length of 8 mm.

The form of the glabella of this species is not unlike that of *Pagodia macedo*, but its anterior lobe is much broader.

Formation and locality.—Upper Cambrian, lower portion of Chao Mi Tien formation, in a hard, dark limestone; 2.7 miles southwest of Chao Mi Tien and Pagoda Hill, a mile west-southwest of Tai An Fu, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PAGODIA DOLON, new species.

This species is represented by two specimens of the head exclusive of the free cheeks. Glabella elongate, subquadrilateral, moderately convex; a very obscure trace of a posterior pair of short furrows is all that can be seen on the outer surface; occipital furrow rather narrow, clearly impressed, and arching slightly forward at the center; occipital ring narrow at the sides, increasing gradually in width to the center, where it is strong and moderately convex; dorsal furrow strong at the sides and front of the glabella.

Fixed cheeks a little more than one-half the width of the glabella, convex, and sloping outward and downward from the dorsal furrow; back of the palpebral lobes they slope gently to the furrow within the posterior margin and anteriorly more rapidly to the furrow within the frontal rim; palpebral lobes small, about one-fourth the length of the head; postero-lateral limb short, and marked by a strong, rounded furrow within the narrow, slightly elevated posterior margin; frontal rim rounded, narrow, and separated from the glabella by a strong, rounded, rather deep furrow, which becomes more shallow in front of the fixed cheeks.

Surface marked by numerous medium-sized punctæ, with very fine punctæ, visible only under a strong lens, between them.

The largest specimen of the species has a length of 5.5 mm., with a width at the palpebral lobes of 8 mm.; the glabella has a length of 3 mm., with a width of 2.5 mm.

This species differs from the other species of the genus in its shorter, broader glabella, and more convex fixed cheeks.

Formation and locality.—Upper Cambrian, lower portion of Chao Mi Tien formation, in hard, dark limestone; 2.7 miles southwest of Chao Mi Tien, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PAGODIA MACEDO, new species.

This species is represented by a single specimen of the head, exclusive of the free cheeks. Glabella elongate, subquadrangular, narrowing very slightly toward the broadly rounded, nearly transverse front, as indicated by the cast of the interior of the crust; surface marked by two pairs of shallow furrows that penetrate a short distance on each side and separate the glabella into three subequal lobes; occipital furrow rounded and strong; occipital ring unknown; dorsal furrow strong, rounded, and clearly separating the moderately convex glabella from the sloping fixed cheeks.

Fixed cheeks slightly convex, sloping gently from the dorsal furrow to the palpebral lobe, more rapidly to the furrow within the pos-

terior margin, and anteriorly to the front margin; palpebral lobes situated about midway between the front and the posterior margins of the head, small and short, not much over one-fifth the length of the head; frontal rim narrow, wire-like, and separated from the glabella and fixed cheeks by a rounded furrow of moderate depth.

The crust is rather thick, the outer surface marked by scattered shallow punctæ, with very fine punctæ, as shown by a strong lens, between them. Length of head exclusive of occipital ring, 7.5 mm.

This species is closely related to *Pagodia lotos*. It differs in the form of the frontal rim and the more uniform slope of the glabella toward the front. From *P. bia* it differs in the more rapid downward slope of the front of the glabella and in the parallel or slightly contracting sides of the glabella.

Formation and locality.—Upper Cambrian, lower portion of Chao Mi Tien formation, in gray fossiliferous limestone; Chao Mi Tien, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus PTEROCEPHALUS Roemer.

PTEROCEPHALUS ASIATICA, new species.

This species is represented by fragments of the anterior portion of the head and of the pygidium. Glabella truncato-conical, moderately convex, narrowing gradually toward its rounded front; surface marked by three pairs of short furrows, the posterior of which separate rather small oval lobes at the postero-lateral angles; occipital furrow narrow and slightly impressed; occipital ring of medium width and nearly flat; dorsal furrow narrow, but distinctly marked.

Fixed cheeks about two-thirds the width of the glabella opposite the palpebral lobes, slightly convex, and crossed by strong, low, ocular ridges; postero-lateral limbs unknown; frontal limb very broad and slightly concave; just in front of the glabella there is a faint depression, formed by a slight change in the slope of the frontal limb, that extends across a short distance in front of the palpebral lobe; frontal rim narrow, slightly rounded, and marked by irregular striæ parallel to the margin.

Surface of the glabella and fixed cheeks slightly roughened by what appear, under a strong lens, to be very fine granulations; the frontal limb is marked by irregular, raised lines that radiate from the front of the glabella and ocular ridges outward toward the front margin; these raised lines are very irregular and more or less inosculating on and near the transverse depression of the frontal limb in front of the glabella and ocular ridges. On a head 23 mm. in length the frontal limb has a length of 11.5 mm. and the glabella and occipital ring 11.5 mm., with a width at the palpebral lobes of 18 mm.

Fragments of the pygidium associated with the head show that it had a slender, moderately convex axis, with more than 8 rings, and that the pleural lobes were moderately convex, flattening out on a broad, planulate margin, the furrows on the axis extending out across the pleural lobes and nearly fading away on the broad margin; a faint trace of a very narrow, short pleural groove is shown on two of the pleural segments. Surface of the pygidium slightly roughened by what appears to be, under a strong lens, a very fine granulation.

Formation and locality.—Middle Cambrian. In gray crystalline limestone, associated with *Damesella blackwelderi;* 3¼ miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTEROCEPHALUS BUSIRIS, new species.

This species is represented by two specimens of a pygidium that is quite distinct from the pygidium associated with *P. asiatica*. The axis is elongate, slightly convex, and converging uniformly to about half its width at the posterior end; marked by eight or more narrow, distinct, transverse furrows that divide it into eight or more transverse rings and an elongate terminal portion. Pleural lobes slope gently from the dorsal furrow down toward the margin; they are marked by the continuation of the distinct transverse furrows of the axis, that extend obliquely backward out to the margin, as far as can be determined; there is a slight indication of a pleural groove on the outer half of the pleural lobe. The pleural lobe is separated from the broad border by a slight elevation of the point of union of the border and pleural lobe, the slope of the two being approximately the same from the margin to the axis; a sharp ridge originates on the front side of each pleural segment a little distance out from the axis, and extends out across the border to the margin, leaving a concave space between the sharp ridges over the entire extent of the border; from the elongate terminal segment of the axis a narrow, double ridge continues backward to the border, which is here slightly incurved.

Surface finely granular under a strong lens.

This species differs from *P. asiatica* in the form of the segments of the pleural lobes and margin.

Formation and locality.—Upper Cambrian, lower portion of Chao Mi Tien formation, in dark, compact limestone; 3 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

A specimen referred to this species also occurs in the lower portion of the Chao Mi Tien formation, two-thirds of a mile west of Tai An Fu, in Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus PTYCHASPIS Hall.

PTYCHASPIS ACAMUS, new species.

This species is represented by specimens of the glabella and fragments of the fixed cheeks. The glabella is moderately convex at the back and strongly convex on the frontal lobe. It is divided by a strong, backward-arching furrow that separates the posterior portion as a transverse lobe and the anterior as a large lobe about as long as broad. The latter is marked by two narrow, short, slightly impressed furrows on the sides of the lobe; occipital furrow strongly rounded, deep, and arching forward at the center; occipital ring about the middle of the posterior lobe of the glabella nearly flat, and with a small, sharp node at the center near the back margin; frontal rim a rounded, narrow border in front of the deep, narrow dorsal furrow; dorsal furrow narrow and deep opposite the palpebral lobe.

Fixed cheeks rise rapidly from the dorsal furrow. They are narrow and convex; palpebral lobes unknown. The anterior lobe of the glabella slightly overhangs the dorsal furrow, which is deep and rounded.

Surface marked with low, large pustules and very faint punctæ. The type specimen of the head in the collection has a length of 11 mm. with a width of 6 mm.

This species is characterized by the form of the large front lobe, the strong transverse furrows, and narrow posterior lobe of the glabella, and its peculiar surface.

Formation and locality.—Middle Cambrian, central portion of the Chang Hsia formation; Chao Mi Tien, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHASPIS CACUS, new species.

General form of head, exclusive of the free cheeks, subrhomboidal, rounded in front, strongly convex. Glabella moderately convex over the posterior portion, strongly convex at the frontal lobe; posterior portion is divided into two lobes, of about equal width, by the broad, rounded, transverse posterior furrow and a narrow, slightly impressed anterior furrow, both of which arch slightly backward toward the center; the frontal lobe is about as long as the two posterior lobes and arches with uniform curve over to the dorsal furrow; it is convex but not globose; it is marked about midway on each side by a short, very lightly impressed narrow furrow, which penetrates it at right angles to the dorsal furrow; occipital furrow broad, strong, and arching slightly forward at the center; occipital ring about as wide as the posterior lobe of the glabella, moderately convex, and arching slightly forward near the center; dorsal furrow strongly

defined at the sides and somewhat less so in front of the glabella; a shallow pit occurs opposite the antero-lateral angle of the glabella.

Fixed cheeks narrow and convex; they slope gently backward and merge into the postero-lateral limb, and forward in advance of the palpebral lobe slope rapidly downward to the rounded frontal limb; palpebral lobes broken away, but from the form of the fixed cheek they appear to have been about one-third the length of the head; postero-lateral limbs about as long as the width of the glabella, and marked by a broad, strong furrow within the narrow postero-lateral margin; frontal lobe and rim united to form a rounded, downward curving frontal border of the head, separated from the glabella by the strong dorsal furrow.

Surface marked by numerous irregularly placed pustules except in the furrows of the glabella, dorsal furrow, and furrow on the postero-lateral limbs. The type and only specimen of the head in the collection has a length of 17 mm., with the glabella 10 mm. in width and 11 mm. long.

In size and general appearance this species may be compared with *P. ceto*. It differs in its strongly pustulose surface, less convex glabella and fixed cheeks, and in the form of the frontal border of the head. At first sight it is apparently identical with *P. calyce*, but it differs in the form of the transverse furrows and the frontal lobe of the glabella, which in *P. calyce* is globose, like that of *P. ceto*.

Formation and locality.—Upper Cambrian, upper portion of the Chao Mi Tien formation; 2.7 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHASPIS CADMUS, new species.

This species is represented by more or less fragmentary specimens of the central portions of the head, exclusive of the free cheeks. Glabella moderately convex at the back and strongly convex at the front, marked by a posterior transverse furrow that arches slightly backward, cutting off a narrow lobe between it and the dorsal furrow; anterior lobe a little longer than wide, and marked by a pair of short, narrow furrows opposite the anterior end of the palpebral lobe; the anterior lobe is convex, but not globose; occipital furrow strong; occipital ring unknown; dorsal furrow strong and rather deep.

Fixed cheeks very narrow and diappearing into the dorsal furrow in front of the palpebral lobe; posteriorly they slope downward as an irregular ridge to the postero-lateral limb; palpebral lobes about one-fourth the length of the head and marked by a deep groove within the narrow rim; frontal limb narrow and sloping outward and downward to the front margin from the broad, strong, dorsal furrow; it is marked by two transverse rows of large tubercles; postero-lateral limbs unknown.

The surface of the head, except the furrows, is thickly covered with large pustules. A glabella 11 mm. in length has a width of 8 mm.; none of the specimens are sufficiently perfect to give measurements for the entire length of the head.

This species is characterized by the very narrow fixed cheeks and strongly pustulose surface. It is associated with *P. calchas*.

Formation and locality.—Upper Cambrian, lower portion of Chao Mi Tien formation, in a gray, somewhat coarse, fossiliferous limestone; 2.7 miles southwest of Chao Mi Tien, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHASPIS CALCHAS, new species.

Of this species only more or less imperfect specimens of the central portions of the head, exclusive of the free cheeks, are known. Glabella slightly convex on the posterior half and moderately convex at the frontal lobe; it is divided by two transverse, rather strong, shallow furrows into two narrow lobes that arch slightly backward and an anterior lobe that measures a little more than half the length of the glabella; a pair of very slightly impressed and short furrows mark the side of the frontal lobe a little back of the center; occipital furrow broad, shallow, and about the same strength as the two furrows crossing the glabella; occipital ring narrow at the sides, increasing in width toward the center, where it rises at the back above the general level of the glabella; dorsal furrow broad and rounded.

Fixed cheeks scarcely more than a very narrow ridge rising from the broad dorsal furrow to the palpebral lobe and sloping gently backward into the postero-lateral limb and forward in front of the palpebral lobe into the frontal border of the head; palpebral lobe about one-fourth the length of the head and marked by a strong furrow within the narrow rim; frontal limb nearly flat, of medium width, and sloping forward and downward from the dorsal furrow to the frontal margin; postero-lateral limbs about as long as the width of the glabella, and marked by a broad, shallow furrow within the narrow posterior margin.

The cast of the interior surface of the test appears to be minutely punctate under a strong lens, and fragments of the exterior appear to be smooth. The largest specimen of the head in the collection has a length of about 22 mm.; a specimen 11 mm. in length has a glabella 5 mm. in width, with a fixed cheek a little less than 2 mm. in width from the sides of the glabella across the dorsal furrow to the furrow on the palpebral lobe.

This species differs from the described species of the genus in the low convexity of the glabella, the uniformity of the occipital and two posterior furrows of the glabella, and the apparently smooth surface.

Formation and locality.—Upper Cambrian, lower portion of Chao Mi Tien formation, in a gray, somewhat coarse, fossiliferous limestone; 2.7 miles southwest of Chao Mi Tien, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHASPIS CALLISTO, new species.

Of this species only the central portions of the head, exclusive of the free cheeks, are known. Glabella moderately convex, and divided into a narrow posterior lobe by a broad, rounded, deep, transverse furrow that curves slightly backward, and an anterior lobe, about as long as wide, marked upon its lateral slopes by two pairs of short, narrow furrows; it is broadly rounded, almost transverse in front, and its sides are sub-parallel; occipital furrow broad and deep and arching slightly forward at the center; occipital ring narrow at the ends, widening and rising gradually toward the center, which appears to have been elevated above the general surface of the head; dorsal furrows strong and deep.

Fixed cheeks narrow, rising abruptly from the dorsal furrow and extending laterally to the furrow within the rim of the palpebral lobe; they slope gently backward to the postero-lateral limb, and more abruptly forward to a strong furrow that separates the frontal rounded margin of the head from the glabella; frontal limb and rim combined in a rounded frontal border, which corresponds in its section to about the same curvature as the section of the furrow between the border and the glabella; postero-lateral limbs about as long as the width of the glabella, and marked by a broad, rather deep groove within the narrow posterior margin.

Surface of the cast of the interior of the test with numerous rather large scattered punctæ and very fine punctæ seen only with the aid of a strong lens; a fragment of the outer surface shows it to have been strongly punctate, with fine punctæ corresponding to the punctæ seen on the cast of the interior. The largest head in the collection has a length of 13 mm.

This species is strongly characterized by the broad, strong posterior furrow and narrow posterior lobe of the glabella, and the sub-quadrate, moderately convex frontal lobe; also the elevated occipital ring and punctate surface.

Formation and locality.—Upper portion of the Chao Mi Tien formation, at the same horizon as *P. cacus* and *P. ceto;* 2.7 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHASPIS CALYCE, new species.

In general form, convexity, and size the corresponding parts of this species follow that of *P. ceto.* It differs from the latter in having a

strongly pustulose surface instead of irregular, more or less concentric ridges and furrows. The largest specimen of the head in the collection has a length of 17 mm.

Formation and locality.—Upper Cambrian, Chao Mi Tien formation, about the middle of the formation; 7.5 miles east of Chao Mi Tien, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHASPIS CAMPE, new species.

This species is represented by a fragment of a small head that is so distinct in its surface granulation, large eye lobe, and frontal portion of the head that it can not be readily confused with any other species. The glabella is divided by two narrow, transverse, slightly backward-curving furrows into two narrow lobes and a large anterior lobe that is marked by two pairs of short, very narrow furrows on the lateral slopes; the anterior lobe is about as long as wide, slightly convex behind and strongly convex in front, but not at all globose or tumid; it is broadly rounded, almost transverse in front, and has parallel sides; frontal limb very narrow in front of the glabella, widening at the sides; it is separated from a downward-sloping frontal rim by a very narrow transverse furrow; the frontal rim is very slightly convex, and from two to three times as wide as the frontal limb in front of the glabella; dorsal furrow narrow and deep on the sides, and little more than a line in front of the glabella.

Fixed cheeks very narrow at the front and back and merging into a large palpebral lobe at the center; they rise rapidly from the dorsal furrow and arch over into the furrow within the narrow palpebral lobe; palpebral lobe extends from opposite the anterior pair of furrows on the frontal lobe of the glabella back to the posterior transverse furrow.

Surface marked by large, low, closely arranged granulations or pustules. This is a small species, the type specimen of the glabella having a length of 4 mm. with a width of 2 mm.

Formation and locality.—Upper Cambrian, Chao Mi Tien formation, about the middle of the formation; 7.5 miles east of Chao Mi Tien, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHASPIS CETO, new species.

Head, exclusive of the free cheeks, sub-rhomboidal in outline, strongly convex. Glabella large, strong, with very convex frontal lobe, sides sub-parallel, front broadly rounded; two strong glabellar furrows cross transversely from side to side, dividing the glabella into two rather narrow posterior lobes and an anterior, globose lobe that

slightly overhangs the frontal rim; occipital furrow about as strong as the two glabellar furrows; occipital ring narrow and slightly rounded, and elevated at the center; dorsal furrows strong and deep on the sides and in front of the glabella.

Fixed cheeks with the dorsal furrow about two-thirds the width of the glabella, the fixed cheeks forming an elevated ridge at the palpebral lobe, with an elevated short ridge opposite the anterior end of the palpebral lobe, that is crossed by three transverse ridges, as seen in the cast of the inner surface; in front of the elevated portion the cheek drops gently to the frontal rim; back of the palpebral lobe the cheek slopes gently and merges into the postero-lateral limb; palpebral lobe narrow, elongate, a little more than one-half the length of the head, and separated from the fixed cheek by a narrow, deep furrow; postero-lateral limb about as long as the width of the glabella at the base, and marked by a broad, deep, rounded groove, within the sharp, elevated, posterior margin; frontal limb very short and sloping downward into the rounded frontal rim; the frontal limb and rim form scarcely more than the outer border of the strong dorsal furrow.

Outer surface unknown, as in all the specimens the test clings to the matrix; this latter fact indicates that it was roughened, probably tuberculose. The cast of the frontal lobe of the glabella shows a number of irregular, concentric ridges and grooves sub-parallel to the frontal margin. The largest head in the collection has a length of 14 mm., with a width at the palpebral lobes of 17 mm.; the glabella was 8 mm. in width, with a length, including the occipital ring, of 14 mm.

This species differs from *Ptychaspis cacus* in the globose, overhanging frontal lobe of the glabella, and the form of the frontal rim, features that also separate it from *P. cadmus* and *P. calchas*. From *P. acamas* it differs in the form of the frontal lobe of the glabella and the transverse lobe back of it. The globose glabella resembles that of *P. granulosa* Owen, except that it is more globose and overhangs the frontal border. *P. granulosa* has a different form from the other Chinese species.

Formation and locality.—Upper Cambrian, in the lower portion of the Chao Mi Tien formation, in a fossiliferous, coarse gray limestone. Chao Mi Tien; two-thirds of a mile west of Tai An Fu; Pagoda Hill, a mile west-southwest of Tai An Fu; 2.7 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHASPIS, species undetermined.

There are several species of *Ptychaspis* that occur in the upper Cambrian zone that are too imperfect for description. One of these has the general form of *P. campe*, but it differs in the exceedingly

narrow fixed cheeks and flat frontal border, while having the same type of pustulose surface. It occurs in the upper portion of the Chao Mi Tien formation, at Chao Mi Tien, Shangtung, China. Other fragments representing species of this genus are too imperfect for identification or description.

Genus PTYCHOPARIA Hawle and Corda.

PTYCHOPARIA ACLIS, new species.

The slightly convex central portions of the head of this species are preserved. The species is distinguished by the breadth of the glabella in front and three pairs of short, well-defined furrows that divide the sides of the glabella into four subequal lobes; an occipital spine; and narrow rounded frontal rim, cut around in front nearly to the median line by the facial sutures. Ocular ridge well defined. Surface unknown.

Formation and locality.—Lower Cambrian, Man To formation; Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHOPARIA (?) BATIA, new species.

Head, exclusive of the free cheeks, sub-rhomboidal, moderately convex; glabella truncato-conical; a specimen with a length of 11 mm. has a width at the base of 11 mm., and at the broadly rounded, almost transverse front of 7 mm.; very faint traces are shown of a posterior pair of furrows; occipital furrow nearly straight, shallow, rounded, and narrow; occipital ring strong, very slightly convex, and slightly wider at the center than at the ends; it is marked at the center, near the occipital furrow, by a minute node; dorsal furrow distinctly but not deeply marked.

Fixed cheeks wide and slightly convex, nearly flat between the glabella and palpebral lobe, and curved downward in front to the frontal rim and backward to the furrow within the posterior margin; ocular ridge narrow and low, but distinctly shown; posteriorly it passes into the palpebral lobe; palpebral lobe small, and situated a little back of a transverse line drawn through the center of the head; postero-lateral limb large, about as long as the base of the glabella is wide, and marked by a strong furrow within the elevated posterior margin. The front of the glabella and of the fixed cheeks curves down into a shallow furrow, from which the frontal rim rises before curving over to form a thick frontal margin, which is marked by longitudinal raised striæ.

Surface smooth under a strong lens. The largest of three specimens of a head has a length of 20 mm., with a width at the palpebral lobes of 26 mm.

This species is characterized by its large size, concave frontal rim, and nearly smooth glabella. In view of the occurrence of heads of the genus *Dorypygella* at about the same horizon, which resemble this, the generic reference is somewhat doubtful. A somewhat similar head occurs in the upper portion of the Chao Mi Tien limestone at about the same horizon, 9 miles north of Hsin Tai Hsien.

Formation and locality.—Upper Cambrian, Chao Mi Tien formation; 2.7 and 3 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China. A form apparently identical was found by Mr. Blackwelder in limestone blocks in talus at Chao Mi Tien.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCOPARIA (?) BROMUS, new species.

This species is represented by the central portions of the head, exclusive of the free cheeks. Glabella moderately convex, truncato-conical, rounded in front, and apparently without furrows; occipital furrow transverse and clearly defined; occipital ring strong and moderately convex; dorsal furrow broad and shallow.

Fixed cheeks nearly as wide as the glabella opposite the palpebral lobe; they rise slightly from the dorsal furrow to the palpebral lobe, and slope gently backward to the postero-lateral limb and forward to the frontal limb; palpebral lobe narrow, about one-third the length of the head; ocular ridge rounded and faintly defined; frontal limb of medium width, slightly convex, and sloping gently down to a rounded furrow that separates it from the flattened frontal rim, which is about one-half as wide as the frontal limb.

The surface is slightly roughened by minute granulations, as seen with the aid of a strong lens. The largest specimen of the head in the collection has a length of 7 mm.

This species is characterized by the rounded, smooth appearance of the glabella, fixed cheeks, dorsal furrow, and frontal limb.

Formation and locality.—Middle Cambrian, Ku San shale formation; 2.5 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHOPARIA CEUS, new species.

Outline of head, exclusive of free cheeks, transversely subrhomboidal, broadly rounded in front, convex; glabella conical, moderately convex, and marked by two pairs of short, shallow furrows that extend in but a short distance on the sides; occipital furrow rounded, very distinct, and continued outward on the postero-lateral limbs, where it is stronger and deeper; occipital ring narrow at the sides, gradually

increasing in width toward the center, where it is slightly convex, and marked at the center by a minute sharp tubercle; dorsal furrow strong and rather deep about the glabella.

Fixed cheeks about the same width as the glabella, moderately convex; they slope gently from the dorsal furrow to the palpebral lobe, and backward to the furrow of the postero-lateral limb; in front they slope rather rapidly and merge into the frontal limb; palpebral lobes small and situated about their own length from the posterior margin of the head; ocular ridge very faint, scarcely perceptible except by turning the specimen in the light; frontal limb slightly convex, sloping gently downward, and divided midway by a longitudinal furrow that extends from the front of the glabella to the furrow within the frontal rim; each side of the longitudinal median furrow the frontal border extends outward and backward, merging into the fixed cheeks without any interruption in the convexity of the slope; frontal rim narrow, nearly flat, and separated from the frontal limb by a very shallow groove which is little more than a change in slope of the frontal limb to the nearly flat frontal rim; postero-lateral limbs very short.

Surface minutely granulose under a strong lens, with a few scattered larger granules. The largest head of the species in the collection has a length of 4 mm., with a width at the palpebral lobes of nearly 5 mm.

This species is characterized by the longitudinal furrow in front of the glabella, which resembles the longitudinal furrow frequently seen in the frontal limb of the heads of *Agnostus*.

Formation and locality.—Middle Cambrian, Ku San shale formation; 2.5 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHOPARIA CONSTRICTA, new species.

The convex central portions of the head, exclusive of the free cheeks, are subquadrilateral in outline; glabella subcylindrical, narrowing slightly toward the front; only faint indications of glabellar furrows; occipital furrow narrow, clearly defined but shallow; occipital ring strong, narrow at the sides and broad at the center; fixed cheeks about as broad as the glabella; ocular ridges strong and merging into the rather long palpebral lobes; frontal limb well defined by the ocular ridges and narrow, slightly flattened, frontal rim.

Surface slightly roughened by minute irregular raised lines.

Formation and locality.—Lower Cambrian, Man To formation, lower part of southeast slope of Hu Lu Shan; 2.5 miles south of Yen Chuang, Hsin Tai, Shangtung, China.

PTYCHOPARIA DRYOPE, new species.

The head representing this species is of the same type as that of *Ptychoparia titiana*, from the base of the Chang Hsia formation. It differs from it in having a more elongate glabella, which is more transverse in front. It is also not probable that species of this character would range through 2,500 feet of limestone. It is often the case that heads that appear to have the general features of Ptychoparia are found to belong to other genera when the thorax and pygidium are known. This species is associated with *Ptychaspis ceto*, *Illænurus dictys*, *Menocephalus depressus*, and *Cyrtoceras cambria*.

Formation and locality.—Upper Cambrian, upper portion of Chao Mi Tien formation; Pagoda Hill, 1 mile west-southwest of Tai An Fu, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHOPARIA GRANULOSA, new species.

The gently convex central portions of the head, exclusive of the free cheeks, are all that is known of this species. These indicate a rather broad, semicircular head, with small free cheeks; wide fixed cheeks; narrow, short, convex glabella and narrow, flattened frontal rim; glabella marked by three pairs of faintly impressed but clear glabellar furrows; frontal space between the glabella and rim broader than the frontal rim and slightly convex; ocular ridge narrow, clearly defined, and merging into a rather small eye lobe.

Surface finely granulose.

Formation and locality.—Lower Cambrian, Man To formation; Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHOPARIA IMPAR, new species.

This species is represented by many fine specimens of the rather convex central portions of the head. The form of the parts preserved is not unlike that of *Ptychoparia aclis*. They differ in being more convex and stronger and in the absence of an occipital spine and the presence of rather faint glabellar furrows. Ocular ridge rounded and rather strong. Surface finely punctate.

Formation and locality.—Lower Cambrian. Man To formation. Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHOPARIA IMPAR, variety?.

This variety differs from the type of the species in having more distinctly defined glabellar furrows, slightly narrower frontal rim, and more rounded frontal margin to the glabella. There are several specimens of the head from one locality, which appear to vary among themselves as much as some of them vary from *P. impar*. The latter and the forms referred to the variety come from the upper portion of the Man To formation.

Formation and locality.—Lower Cambrian, upper portion of Man To formation, in shaly sandstone and limestone: Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHOPARIA LIGEA, new species.

Head, exclusive of free cheeks, subquadrilateral in outline, moderately convex; glabella almost of the same width from the posterior margin to the rounded front: three pairs of furrows are faintly but clearly indicated; occipital ring strong; occipital furrow shallow but extended out on the lateral limbs as a strong furrow. Fixed cheeks nearly as wide as the glabella; palpebral lobes short and small; ocular ridges narrow and strongly defined; frontal limb slightly convex to where it merges into the broad, shallow furrow that extends nearly out to the front margin; postero-lateral limbs rather long.

Surface slightly roughened by minute, irregular, raised lines that can be seen only with a strong lens.

Formation and locality.—Lower Cambrian. Middle of Man To formation. Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHOPARIA MANTOENSIS, new species.

Only the central portions of the moderately convex head of this species are definitely known. It is characterized by the broad frontal space and flat frontal rim; the sides of the glabella converge slightly toward the front margin, which is broadly rounded; glabellar furrows indicated by three very faint depressions on each side. Occipital furrow relatively shallow and rounded; fixed cheeks rather broad; eye lobe occupies the central third of the distance from the posterior margin to the anterior flattened rim; ocular ridges not strongly marked.

Surface slightly roughened by almost microscopic, irregular raised lines.

An associated free cheek has a long, slender postero-lateral spine.

Formation and locality.—Lower Cambrian. Man To formation. At Chang Hsia and 1 mile south, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHOPARIA TELLUS, new species.

All that is known of this species is the central part of the head, exclusive of the free cheeks. The specimens occur on the surface of shaly limestone, and are probably somewhat compressed; their convexity is relatively slight. Glabella large, convex, and nearly as wide in front as at the base; three pairs of glabellar furrows are indicated on the somewhat eroded outer surface of two specimens; occipital furrow shallow, narrow, and rounded, but quite distinct; occipital ring narrow at the sides, increasing in width and inclining backward toward the middle, where it rises to the base of a strong spine, which is directed upward and backward; the spine is nearly straight, and about as long as the length of the head; dorsal furrow clearly defined on the sides and in front of the glabella.

Fixed cheeks slightly convex and less than half the width of the glabella; palpebral lobes rather large; ocular ridges clearly defined and merging into the palpebral lobe; frontal limb short, slightly convex, and merging into the flattened frontal rim, the line of demarcation between the two being very slight; posterior lateral limbs small and short.

Surface unknown.

The largest head in the collection has a length of 10 mm. with a width of 11 mm. at the outer edges of the palpebral lobes.

This species is most nearly related to *Lonchocephalus hamulus*. It differs in having wider fixed cheeks and in the proportion of length of the frontal limb and rim as compared with the glabella.

Formation and locality.—Middle Cambrian. Lower portion of Chang Hsia formation. Two miles south of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHOPARIA TENES, new species.

Of this species only the moderately convex central portions of the head are known. Glabella prominent, moderately convex, narrowing very gradually toward the broadly rounded front; furrows only faintly indicated; occipital ring strong and bearing a broad base of a spine that extends obliquely upward and backward; occipital furrow shallow on the sides and scarcely perceptible at the center; dorsal furrow rounded and clearly defined. Fixed cheeks slightly convex and about one-third the width of the glabella; the length of the palpebral

lobes is about one-third the distance from the posterior to the front margin; ocular ridge low, broad, and marking quite distinctly the division between the lateral fixed cheeks and the rather abrupt downward slope of the short frontal limb, which merges into the rather broad, flat, frontal rim.

Surface minutely granulose under a strong lens. The largest head in the collection has a length of about 6 mm., exclusive of the occipital spine. This species is distinguished by the strong, occipital spine, large eye lobes, narrow, fixed cheeks, and the form of the frontal rim.

Formation and locality.—Middle Cambrian. At base of Chang Hsia formation, just above the Man To shale. One mile east-southeast of Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHOPARIA, species undetermined.

A single specimen of the central portion of a head that appears to be closely related to *P. tenes* occurs on the surface of a fragment of limestone. It has a similar slender, long, occipital spine, narrow, fixed cheeks, and flattened frontal rim. It occurs in the upper portion of the Chang Hsia formation, near the middle of the Chang Hsia oolitic limestone, 2 miles south-southeast of Kao Chia Pu, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHOPARIA TITIANA, new species.

Head subquadrilateral in outline, exclusive of the free cheeks; moderately convex. Glabella gently convex; broadest at the base, narrowing midway, and with the sides nearly parallel from the center to the broadly rounded front; glabellar furrows shallow, there are three on each side that penetrate to the central third of the glabella and divide it into two small central lobes, a short terminal lobe, and a posterior lobe that is broad at the sides and narrow toward the central third; occipital furrow narrow; occipital ring narrow at the sides and gradually thickening toward the center to form the base of a rather strong spine of unknown length; dorsal furrow shallow, but clearly defined.

Fixed cheeks of medium width, about two-thirds the width of the glabella; palpebral lobes central and about one-third the length from the posterior to the frontal margins of the head; ocular ridge narrow, clearly defined, it starts near the front line of the glabella and extends obliquely backward and merges into the rim of the palpebral lobe; postero-lateral limbs short and marked by a broad, shallow furrow; frontal limb convex, prominent, about as long as the fixed cheeks at

the eye lobes; at the front it slopes into the rounded groove back of the narrow, slightly flattened, frontal rim.

Surface slighlty roughened over the central portions; on the frontal limb a network of fine, irregular, raised lines extends from the dorsal furrow and ocular ridges to the furrow inside the frontal rim.

Observations.—This species is associated with *Ptychoparia Liostracus thraso*. Its strong frontal limb and occipital spine distinguish it from other species.

Formation and locality.—Middle Cambrian. Base of Chang Hsia formation in oolitic limestone about 2 miles southwest of Yen Chuang, and 1 mile east-southeast of Chang Hsia, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHOPARIA THEANO, new species.

Head small, moderately convex; glabella subquadrilateral, moderately convex, a little narrower in front than at the base, and without glabellar furrows; occipital ring practically a continuation of the glabella, as the shallow occipital furrow barely indicates it; dorsal furrows narrow at the sides of the glabella, and very obscure in front of it.

Fixed cheeks a little wider than the glabella and nearly flat from the dorsal suture to the palpebral lobes; palpebral lobes large, situated opposite the central portion of the glabella; ocular ridges low and broad, and very clearly defining the lateral portions of the fixed cheeks from the frontal limb; frontal limb narrow in front of the glabella, sloping downward to the broad, shallow furrow that merges into the broad, almost flat, frontal rim; postero-lateral limbs short; a narrow, sharp furrow extends along their posterior margin from the glabella to the facial suture, just within the posterior margin.

Surface minutely granular under a very strong lens. The largest head has a length of 5 mm.

This species is distinguished by the broad, flat, fixed cheeks, convex, smooth glabella, large palpebral lobes, and nearly flat frontal margin.

Formation and locality.—Middle Cambrian. Base of Chang Hsia formation, in gray oolitic limestone. Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHOPARIA TOLUS, new species.

Of this species only a single fragmentary head is known; this is much like the corresponding parts of the head of *Ptychoparia Liostracus thraso*, but it differs (*a*) in being less convex, (*b*) in having a more coarsely granulated surface, (*c*) stronger posterior glabellar furrows,

(*d*) broader fixed cheeks, and (*e*) more broadly rounded front to the glabella. The length of the head is 10 mm.; of the glabella, 7 mm.; width of the head including palpebral lobes but not free cheeks, 12 mm.

Formation and locality.—Middle Cambrian. Base of Chang Hsia formation in oolitic limestone; 3 miles north-northeast of Hsin Tai, Hsien, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

LIOSTRACUS Angelin, subgenus of PTYCHOPARIA.

PTYCHOPARIA (LIOSTRACUS) TOXEUS, new species.

Of this species only the central portions of the head are known. The glabella and fixed cheeks are rather strongly convex; glabella prominent, truncato-conical, without furrows, except as indicated by a slight darkening of the surface where the furrows usually occur; occipital groove narrow, but very distinct; occipital ring narrow at the sides, rounded, and of medium width at the center; dorsal furrow strong, rounded, and marked by a slight pit at the antero-lateral angle of the glabella.

Fixed cheeks about one-half the width of the glabella at its base; palpebral lobes small and situated about half way between the posterior and front margins; ocular ridges faintly defined. Frontal limb narrow, convex, and sloping downward to a deep, rounded groove which rises in front to a strong, rounded frontal rim; postero-lateral limbs about one-third longer than the width of the fixed cheeks, a strong furrow extends the entire distance within the posterior margin.

The surface under a strong lens appears to be smooth. The largest head has a length of 6 mm. with a width of 7 mm. at the palpebral lobes, exclusive of the free cheeks.

This species may be compared with *Ptychoparia oweni*, a form that has a wide geographic distribution in the United States, and also ranges from the Middle Cambrian into the Upper Cambrian of the Eureka district in Nevada.[a]

Formation and locality.—Middle Cambrian. Chang Hsia formation in the basal layers just above the shales; a mile east-southeast of Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHOPARIA (LIOSTRACUS) TROGUS, new species.

Head small, transversely quadrilateral, exclusive of the free cheeks; moderately convex; glabella broadly truncato-conical and without

[a] Mon. U. S. Geol. Surv., No. 8, 1884, p. 55.

traces of glabellar furrows; occipital furrow narrow and rather shallow, rising on the back to the rather strong rounded occipital ring; the latter is broad through the central portions, narrowing at the sides; dorsal furrow rounded and well defined. Fixed cheeks about one-half the width of the glabella; palpebral lobes small; ocular ridges very faint; frontal limb very narrow, in fact it is difficult to decide that the dorsal furrows do not unite with a depressed space in front of the glabella that merges into the frontal furrow; the latter is rounded, shallow, and defines the strong, slightly convex frontal rim; postero-lateral limbs short, marked with a very distinct transverse furrow, just within the posterior margin.

Surface apparently smooth under a strong lens.

This species differs from other forms in the very short frontal limb and flattened frontal rim.

Formation and locality.—Middle Cambrian. Chang Hsia limestone, about 50 feet below the Ku San shale. Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHOPARIA (LIOSTRACUS) TUTIA, new species.

Head small, strongly convex; glabella very convex, almost tumid; truncato-conical in outline, and without traces of glabellar furrows; occipital furrow narrow; occipital ring strong and narrow at the sides; none of the specimens show it entire at the center; dorsal furrow narrow and rather deep on the sides of the glabella; not distinctly defined in front.

Fixed cheeks about two-thirds of the width of the glabella; palpebral lobes small, with their posterior end on a line with the longitudinal center of the head; ocular ridges narrow but very clearly defined; frontal limb gently convex, rather short, and very indistinctly separated from the rather broad, almost flattened, frontal rim; postero-lateral limbs strong but short; marked by a strong transverse furrow just within the posterior margin.

Surface minutely granulose. The largest head in the collection has a length of 4 mm. This very pretty little head is of the general type of *Ptychoparia tolus*, but it differs in the greater convexity of the glabella and the form of the frontal limb.

Formation and locality.—Middle Cambrian. Chang Hsia limestone, central portion. Three and one-fourth miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PTYCHOPARIA (LIOSTRACUS) THRASO, new species.

Head subquadrilateral in outline, exclusive of the free cheeks; strongly convex; glabella prominent, convex, sides straight, and converging toward the front from a width of 6 mm. at the base to 4 mm. at the front in a glabella 6.5 mm. long; front arched, and with a pit in the furrow where the sides and front unite; three shallow broad furrows extend nearly to the center from each side, so as to divide the surface into two narrow lobes—a terminal lobe and a strong posterior lobe; occipital furrow strong and arching forward at the center; occipital ring narrow at the sides and gradually increasing in width to the center; dorsal furrow narrow and well defined. Fixed cheeks narrow; palpebral lobes central, and small; postero-lateral limbs short and marked by a broad strong furrow; ocular ridges low, but clearly defined; frontal limb short, gently convex, and sloping into a strong, rounded furrow within the rounded, narrow, prominent frontal rim.

Surface smooth under a strong lens.

A head 10 mm. in length has a width of 11 mm. at the eye lobes.

Formation and locality—Middle Cambrian. Base of Chang Hsia formation, in oolitic limestone, about 2 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

PROAMPYX Frech, subgenus of PTYCHOPARIA.

Proampyx Frech, 1902; Lethæa geognostica, I. Theil, Lethæa Palæozoica, II, p. 66.

Dr. Fritz Frech proposed the genus Proampyx for *Anomocare acuminatum* Angelin on account of the projection of the frontal border into a strong spine. He said:[a] "The peculiar very variously formed group of *Anomocare acuminatum*[b] with pointed glabella, seems to be the forerunner of *Ampyx* and is called *Proampyx*. The difference from the typical *Anomocare* with rounded head shield is striking. The separation of the genus *Proampyx* from the typical Conocephalidæ follows from the transitional forms *Arionellus sulcatus*[c] and *A. difformis*.[d] The spine of *Ampyx acuminatus* is in well preserved examples longer than in Angelin's illustration. The species reminds most of *Ampyx nasutus* Dalman (Orthoceras limestone)."

Doctor Frech in his statement appears to have overlooked the fact that the spine of the genus Ampyx is a spinose extension of the front of the glabella, while the nasute projection of the frontal rim of

[a] Lethæa geognostica, Pt. 1, Lethæa Palæozoica, II, p. 66.

[b] Angelin, Tril. pl. xvii, fig. 7.

[c] *Anomocare* Angelin, Tril., pl. xvi, fig. 6.

[d] Idem, fig. 5.

Anomocare acuminatum is from an entirely different division of the head of the trilobite and in no way can be correlated or compared with the glabella of Ampyx. On this account it is unfortunate that the name Proampyx was given.

A similar nasute projection of the frontal border occurs on the head of the trilobite described as *Ptychoparia? pernasutus* Walcott.[a] The glabella of the latter species is quite unlike that of *Proampyx acuminatum*, being more like that of *Proampyx burea*. On this account it is doubtfully referred to proampyx and it is left under the genus Ptychoparia, with Proampyx as a subgenus, until a further study can be made of all the forms in which the frontal border is extended into the nasute projection.

PTYCHOPARIA (PROAMPYX) BUREA, new species.

Head, exclusive of the free cheeks, quadrilateral in outline, convex. Glabella convex, truncato-conical in outline, with the front broadly rounded; surface marked by two pairs of faintly indicated furrows; occipital furrow rounded, narrow, and distinct; occipital ring narrow at the sides, of medium width, and slightly convex toward the center; dorsal furrow of medium width rather deep and distinct.

Fixed cheeks convex, narrow, and about one-fourth the width of the glabella at the palpebral lobes; they slope gently back to the postero-lateral limbs, and abruptly downward in front of the narrow rounded ocular ridge to the frontal limb; postero-lateral limbs short, marked by a shallow furrow parallel to the margin; frontal limb short, and rising a short distance in front of the glabella into a nasute-like extension of the frontal rim, which rises up in front of the head; to the sides the frontal limb slopes abruptly downward and forward, forming a deep wide groove with the frontal rim; frontal rim not separable from the frontal limb at the sides, but rising immediately in front of the glabella into a broad nasute-like process, the height of which is unknown.

Surface unknown except on the occipital ring, where it is marked by irregular, raised, inosculating lines that give it a granulose appearance. The type and only specimen of the head in the collection has a length of 10 mm., exclusive of the nasute-like projection on the frontal rim.

This species is clearly distinguished by the nasute-like projection on the frontal rim.

This species differs from *Proampyx acuminatum* Angelin, in the short frontal limb and the form of the nasute projection; also in the form of the glabella, and other parts of the central portions of the head.

[a] Mon. U. S. Geol. Surv., 1884, VIII, pl. x, figs. 8, 8b.

Formation and locality.—Upper Cambrian, base of the Chao Mi Tien formation, in a coarse, fossiliferous gray limestone, 3 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus SHANGTUNGIA, new genus.

As there is but one species of this genus, the description of the species includes all that is known of the genus and species. The genus is characterized by the large palpebral lobes, smooth, truncato-conical glabella, and the long spinose extension of the front, which is unlike that of Ampyx, as the latter proceeds from the glabella, while the spine of Shangtungia is from the frontal rim, in the same manner as that of *Proampyx acuminatum* Angelin; but it differs radically from the latter genus and species in the character of the glabella and palpebral lobes.

Genotype.—Shangtungia spinifera.

SHANTUNGIA SPINIFERA, new species.

Outline of head, exclusive of free cheeks and frontal spine, subrhomboidal, moderately convex. Glabella truncato-conical, slightly longer than its width at the base; at the postero-lateral angle of the glabella a small, low lobe extends out into and partially fills up the dorsal furrow; there is also a slight pit in the dorsal furrow opposite a point where a second glabellar furrow usually occurs in similar glabellæ; occipital furrow narrow, distinctly defined at the sides, but very shallow near the center; occipital ring slightly convex, strong, and of equal width from side to side; dorsal furrow deep at the sides and scarcely perceptible in front of the glabella.

Fixed cheeks about two-thirds as wide as the glabella; they rise abruptly from the deep dorsal furrow, and then slope upward to the palpebral lobe; back of the palpebral lobe they drop somewhat abruptly to the postero-lateral limb, and in front to the furrow between the frontal limb and rim; ocular ridge very slight, scarcely perceptible in most specimens; palpebral lobe large, rounded, and rising at the margins above the level of the fixed cheeks; rim of the broad marginal border with an inward slope toward the fixed cheeks, but not any well defined furrow such as usually occurs on the palpebral lobes; the length of the palpebral lobe is about one-half of the distance between the furrow in front of the frontal limb and the posterior margin of the head; postero-lateral limb slender, and extending more than the width of the glabella outward from the dorsal furrow; frontal limb very short and scarcely separable from the downward slope of the front of the glabella; at the sides it merges into the fixed cheeks; it is separated from the frontal rim by a peculiar transverse

furrow; the latter is formed of two slightly forward arching, narrow furrows in front of the fixed cheeks, that merge into a very shallow furrow in front of the glabella; the central portion of the furrow arches slightly backward; the furrows are deepest opposite the antero-lateral angles of the glabella; frontal rim sub-triangular in outline, nearly flat, and extending forward at the center to form the base of a long, slender, rounded spine.

Surface minutely punctate under a strong lens. A head 7 mm. in length, exclusive of the frontal spine, has a width of 9 mm. at the outer margin of the palpebral lobes; the glabella is 2.5 mm. at the base, and with the occipital ring is 5 mm. in length, the flat frontal rim and spine of a head of about the same size has a length of about 8 mm., the spine, at the point where broken off, having a width of 1 mm.

I do not know of any other form closely related to this species. *Proampyx acuminatum* Angelin has a similar nasute projection on the frontal rim, but it differs in the form of the glabella and palpebral lobes and other details of the head. The same is true of the species described as *Ptychoparia pernasutus* Walcott.[a]

Formation and locality.—Middle Cambrian, Ku San shale formation; 2.5 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus SOLENOPLEURA Angelin.

SOLENOPLEURA ABDERUS, new species.

This species is represented by the glabella, occipital ring, fixed cheek, and frontal rim. It is most closely related to *S. acantha*, but differs in the narrower fixed cheeks, and short, rounded, frontal rim. The surface is also marked by larger and many more pustules, which are scattered more or less irregularly over the surface. Three pairs of short glabellar furrows are faintly indicated upon the rounded sides of the somewhat convex glabella. The type specimen has a length of 8 mm., and a larger head associated with it of 12.5 mm.

Formation and locality.—Middle Cambrian, upper portion of the Chang Hsia formation, just beneath the Ku San shale, in a gray, rather coarse limestone; Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

SOLENOPLEURA ACANTHA, new species.

General form of head, exclusive of free cheeks, transversely rhomboidal and rather convex. Glabella prominent, convex, truncato-conical, with width at the base and length about the same; a short,

[a] Mon. U. S. Geol. Survey, VIII, 1884, p. 49, pl. x, fig. 8.

strong furrow marks off two small, sub-trianglar lobes at the postero-lateral angle; a second pair of slightly marked furrows occurs upon the sides, next to the dorsal furrow, about midway of the length of the glabella; the sides slope inward from the base, so as to reduce the width of the rounded front to about two-thirds that of the base; occipital furrow narrow, transverse, and deep; occipital ring narrow at the sides, broadening toward the center, where it is thick and convex; dorsal furrow very distinct at the sides and front.

Fixed cheeks convex, but much lower than the glabella; they are about as wide at the palpebral lobe as the width of the glabella in front; their appearance of convexity is given by their downward slope toward the frontal rim and backward to the furrow just within the posterior margin; palpebral lobe small, situated about midway of the fixed cheek; no traces of ocular ridges are shown; a strong, slightly rounded, frontal rim is separated from the glabella and fixed cheeks by a narrow, rounded, transverse furrow; postero-lateral limb short, and marked by a narrow, deep furrow just within the raised posterior margin.

Surface marked by strong pustules in all parts with the exception of the dorsal furrow and furrow back of the frontal rim.

In general form this species resembles *Solenopleura agno* and *S. abderus*. It differs from the former in the shape and convexity of the glabella and broader fixed cheeks and from the latter in the shape of its glabella, fixed cheeks and frontal rim.

Formation and locality.—Middle Cambrian, Chang Hsia formation, just below the Ku San shale; Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

SOLENOPLEURA ACIDALIA, new species.

The description of *S. agno* applies to this species, except that it does not have the short frontal limb of the latter, and its frontal rim is nearly flat instead of rounded. The surface is smooth with the exception of a few large, low, scattered pustules. The head of the type and only specimen in the collection has a length of 4 mm.

Formation and locality.—Middle Cambrian, central portion of the Chang Hsia formation, in a compact, dove-colored limestone; Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

SOLENOPLEURA AGNO, new species.

General form of head, exclusive of free cheeks, transversely subrhomboidal, convex. Glabella as long as the width at its base, the sides converging from the base toward the rounded front, so as to

narrow the glabella about one-fourth; a very slight trace of a short, posterior pair of furrows can be seen by reflected light; occipital furrow well defined by the downward curvature of the posterior margin of the glabella, and rising of the surface of the occipital ring; the latter is narrow at the sides, gradually widening toward the center, which is most elevated a little in front of the posterior margin; dorsal furrow narrow, but clearly defined at the sides in front of the glabella.

Fixed cheeks about one-half the width of the glabella at the center, rather convex, and sloping somewhat abruptly to the frontal rim; palpebral lobe small, situated about midway of the cheeks; postero-lateral limbs unknown; frontal limb very narrow in front of the glabella, convex, and curving down to the broad groove within the strong, rounded, frontal rim.

Surface marked by low pustules that give it a roughened appearance. The type and only specimen of the head in the collection has a length of 6 mm.

This species is characterized by its broad, short glabella, narrow frontal limb, and peculiar granulose surface.

Formation and locality.—Middle Cambrian, upper portion of the Chang Hsia formation, just beneath the Ku San shale, in a rather coarse, light-gray limestone. Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

SOLENOPLEURA BELUS, new species.

This species is represented by a fragment of the head that includes the glabella and fixed cheeks. The glabella is moderately convex and narrows slightly toward the rather broadly rounded front; the surface is marked by a pair of short, oblique, posterior furrows and one anterior pair at about the anterior third; occipital furrow narrow, distinct, arching forward at the center and considerably deeper toward the end; occipital ring clearly defined, of moderate width, and slightly convex; dorsal furrow narrow and clearly defined.

Fixed cheeks narrow, scarcely more than a ridge between the dorsal furrow and the palpebral lobe; posteriorly they slope downward to a long postero-lateral limb and anteriorly drop rather rapidly to the frontal limb; palpebral lobe a little more than one-third the length of the glabella; postero-lateral limb about as long as the width of the glabella in front, deeply grooved along its center by a furrow parallel to the elevated posterior margin; frontal limb short and slightly convex in front of the glabella; it passes into a shallow furrow within a slightly rounded frontal rim; the latter is broken away except at the ends.

Surface marked by numerous scattered, rather small pustules. Length of head 6 mm., with a width at the palpebral lobes of 5 mm.

This species at first suggests *S. agno*, but differs from that and other species from China in its very narrow fixed cheeks and relatively large palpebral lobes.

Formation and locality.—Middle (?) Cambrian limestone and shale, probably of the Ku San shale horizon, just below the Chao Mi Tien formation, at an elevation of 380 feet above the Wön Ho River, 12 miles S. 80° E. of Tai An Fu, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

SOLENOPLEURA BEROE, new species.

The description of the general form *S. agno* applies very closely to this species. It differs from the latter in its broader fixed cheeks, shorter frontal limb, more clearly marked glabellar furrows, and minutely pustulose surface. The type and only specimen of the head in the collection has a length of 4 mm.

Formation and locality.—Upper Cambrian, Chao Mi Tien formation, in a compact, gray, very fossiliferous limestone; 2.7 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus DIKELOCEPHALUS Owen.

DIKELOCEPHALUS (?) BAUBO, new species.

The description of *Dikelocephalus* (?) *brizo* applies to this form, with the exception that *D.* (?) *baubo* has a more rounded front to the glabella, and its frontal rim and border vary somewhat in form. In *D.* (?) *baubo* the palpebral lobe is preserved, and shows it to have been relatively small and short and marked just within the rim by a rather deep furrow. A head of *D.* (?) *baubo* 16 mm. in length has a glabella 12 mm. in length, frontal rim and limb 2 mm., and occipital furrow and ring 2 mm. in length; the glabella has a width of 9 mm. opposite the palpebral lobe. The surface is marked by strong scattered pustules over the glabella; but with little trace of them on the fixed cheeks and frontal rim. The two specimens of the head of this species in the collection vary somewhat in the form of the frontal rim, it being nearly flat in one and slightly concave in the other.

The most nearly related form is *D.* (?) *brizo*.

Formation and locality.—Upper Cambrian, upper portion of the Chao Mi Tien formation, in a compact, hard, fossiliferous, gray limestone; 2.7 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

DIKELOCEPHALUS (?) BRIZO, new species.

This species is represented by the anterior portions of a large, moderately convex head, exclusive of the free cheeks. The glabella is subquadrilateral, with the sides slightly incurved and the front nearly transverse; it is marked by a strong pair of posterior furrows that penetrate obliquely backward nearly to the median line; a second pair incline slightly backward and penetrate to about one-third the distance across; a third pair, narrow and very slightly impressed, extend in at right angles to the sides a little less than one-third the distance; occipital furrow well defined, with a slight, elongate, pit-like depression at the anterior lateral angles of the glabella.

Fixed cheeks very narrow, not much more than a ridge opposite the palpebral lobes; palpebral lobes unknown; ocular ridge rounded, and dividing the fixed cheek into the flat posterior portion and the rather rapidly sloping frontal portion that passes down into the concave frontal limb; frontal limb short, concave, and bordered by a rounded, thick, frontal rim. The fragmentary specimens representing this species indicate a length for the glabella of 22 mm., with a width in front of 14 mm.; the concave frontal limb has a length of 2.5 mm., and the thickened, rounded rim has a length of about 1.5 mm. The fixed cheek at the palpebral lobe has a width of 2 mm.

Surface marked by numerous more or less irregularly placed strong pustules, except in the dorsal furrow and the concave frontal limb. This species is somewhat doubtfully referred to *Dikelocephalus*. The form of the glabella, frontal rim, and narrow fixed cheeks suggest *Dikelocephalus*, but the strongly pustulose surface is not characteristic of the typical forms of the genus.

Formation and locality.—Upper Cambrian, lower portion of the Chao Mi Tien formation, in coarse, gray, fossiliferous limestone; Chao Mi Tien, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus CREPICEPHALUS Owen.

CREPICEPHALUS DAMIA, new species.

Head semicircular in outline, with the postero-lateral angles terminating in round, somewhat incurved, spines. Glabella moderately convex, with the sides narrowing slightly toward the front, which is broadly rounded; length a little greater than its width at the occipital furrow; marked by three pairs of furrows; posterior pair extend obliquely inward and backward so as to almost separate a triangularly shaped lobe; second pair rather faint, extending directly inward a distance of about one-third the width of the glabella, and then curving slightly backward; anterior pair very faint; occipital furrow rather

broad and strongly defined; occipital ring narrow at the ends, rounded, and rather strong in the central portions; dorsal furrows clearly defined on the sides, but obscure in front of the glabella.

Fixed cheeks about one-half the width of the glabella; posteriorly they slope downward into postero-lateral limbs that are about twice as long as the width of the fixed cheeks; toward the front the fixed cheeks slope abruptly downward and merge into the frontal limb; ocular ridges low and broad, merging into the strong palpebral lobe; postero-lateral limbs grooved near the posterior margin by a strong furrow; frontal limb short, almost flat, and sloping abruptly from the front of the glabella down to the strong, nearly flat, frontal rim; the body of the associated free cheek is subquadrilateral in outline, marginal borders strong, clearly defined, and produced behind into a strong, slightly curved, rounded spine.

Thorax unknown.

The associated pygidium is quadrilateral in outline, exclusive of the strong, slightly diverging postero-lateral spines, which are a little longer than the length of the pygidium; sides of the pygidium subparallel or slightly diverging toward the base of the spine; posterior margin nearly transverse; axial lobe prominent, convex, and reaching nearly to the posterior margin; the sides converge slightly toward the bluntly pointed posterior end; divided by three transverse furrows into three segments and a strong terminal portion, which is marked at the point where the axis slopes abruptly downward by the small node on each side; the pleural lobes are limited to a rather large anterior lobe and an obscure secondary lobe, which appears to merge backward into the postero-lateral spine.

Surface apparently smooth under a strong lens; a few scattered punctæ occur on the glabella. The largest head has a length of 10 mm., with a width of 12 mm. at the palpebral lobes.

This species differs from *Crepicephalus iowensis*, to which it appears to be most nearly related, by the form of the frontal limb and rim of the glabella and other details; the pygidium is not as broad, and it also differs in outline.

Formation and locality.—Middle Cambrian, Chang Hsia formation, near upper part, in a dark oolitic limestone; in cliffs 1 mile east of Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

CREPICEPHALUS MAGNUS Walcott.

The only portions of this species in the collection are a fragment of the posterior portion of the glabella and the outer portion of a large free cheek; the fragment shows that the glabella had a width at the base of 12 mm.; also, that there was a narrow, strong occipital groove

and an occipital ring over 3 mm. in width. The surface of the fragment of the glabella is marked by strong pustules, which give it a somewhat granulose appearance. The cast of the fragment of the interior of the free cheek indicates that it was pustulose and that the postero-lateral angle terminated in a long, curved spine.

The two fragments described are so distinctly marked by the coarse granulation and the free cheek by its curved terminal spine that there is little danger of confusing it with any other species.

Formation and locality.—Middle Cambrian, Chang Hsia formation, in a dark oolitic limestone toward the lower portion of the formation; a mile east of Chang Hsia and Chao Mi Tien, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus DOLICHOMETOPUS Angelin.

DOLICHOMETOPUS ALCESTE, new species.

This species occurs at the same locality as *D. deois*, but not in the same bed of limestone. It differs from *D. deois* in having a much more convex glabella, with nearly parallel sides. Glabella marked by a posterior pair of furrows, extending inward and backward so as to nearly cut off a small subtriangular lobe at the base of the glabella, also three pairs of short, faintly impressed furrows that extend in at right angles to the side of the glabella; occipital furrow and ring unknown; dorsal furrow shallow, but well defined.

Fixed cheeks very narrow; they slope down into the strong furrow just within the narrow palpebral lobe and anteriorly slope down to the frontal limb; the rim of the palpebral lobe crosses the narrow free cheek, forming a very short ocular ridge; frontal limb short, nearly flat. The glabella of the only specimen of this species has a length of 12 mm., with a width at the ocular ridges of 8 mm.; the frontal limb has a length of 1.5 mm. The exterior surface under a strong lens shows a few fine scattered punctae. The inner surface of the frontal limb where exposed by a breaking away of a portion of the shell is strongly punctate.

Formation and locality.—Middle Cambrian; near the base of the Chang Hsia formation, in a gray limestone in which great numbers of *Agnostus chinensis*, Dames, occur; 3 miles southwest of Yen Chuang, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

DOLICHOMETOPUS DEOIS, new species.

This species is represented by the central portions of the head. Glabella and fixed cheeks moderately convex; glabella prominent, moderately convex, and marked by three pairs of rather short, very

faintly impressed furrows; the sides of the glabella are sub-parallel for a short distance near the base and then are gently inclined outward to the rounded front margin; occipital furrow shallow, rounded, and merging into the strong occipital ring, the latter is narrow at the sides broadening rather rapidly to the base of a small, backward sloping occipital spine; the front the glabella curves rather abruptly downward, which gives the anterior portion a convex appearance; dorsal furrow shallow and distinctly defined at the sides of the glabella.

Fixed cheeks narrow and slightly convex and sloping posteriorly downward to an elongate postero-lateral limb; in front of the palpebral lobe the cheeks slope abruptly down to the frontal limb; palpebral lobes a little longer than one-third the length of the head. There does not appear to be any definite ocular ridge. The elevated rim of the palpebral lobe approaches closely to the dorsal furrow, where it is merged into the downward slope of the fixed cheek; frontal limb short and slightly convex.

Surface apparently smooth under a strong lens.

On the anterior portion of a cast of the glabella there is indicated a very short fourth furrow close to the antero-lateral angle; the same specimen also shows what is the frontal limb in other heads divided into a short frontal limb and a narrow, slightly upturned rim. The largest head in the collection has a length of 17 mm.

This species differs from the type of the genus *D. speciosus* Angelin in the greater convexity of the glabella, more convex frontal limb, and other minor details of the glabella and fixed cheeks; from *D. dives* it differs in the greater expansion of the glabella in front, and from *D. dercto* in the configuration of the frontal limb.

Formation and locality.—Middle Cambrian. Near the base of the Chang Hsia formation in a gray limestone, which carries great numbers of *Agnostus chinensis* Dames. Three miles southwest of Yen Chuang and 3 miles west of Kao Chia Pu, Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

DOLICHOMETOPUS DERCETO, new species.

This species is known only by the central portions of the head, exclusive of the free cheeks. Glabella moderately convex and expanding slightly in width from the base to the rounded front; the surface is marked by two pairs of rather strong, short furrows opposite the palpebral lobe; occipital ring strong and rather deep; occipital ring narrow at the sides, rising and widening to form the base for a small, sharp, occipital spine; dorsal furrow strong on the sides of the glabella.

Fixed cheeks narrow, convex; palpebral lobe narrow, elongate, almost touching the dorsal furrow in front; postero-lateral limb of

medium length marked by a strong furrow parallel to the posterior margin; frontal limb narrow, slightly concave, and almost concealed by the overhanging, almost tumid frontal portion of the glabella.

Surface smooth under a strong lens. The largest of the three heads representing this species has a length of 7 mm. exclusive of the occipital spine.

Formation and locality.—Middle Cambrian. Lower portion of Chang Hsia formation in a drab-colored limestone, intercalated in green nodular shale. At Yen Chuang and 2 miles south. Hsin Tai, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

DOLICHOMETOPUS DIRCE, new species.

Only the central portions of the head of this species are known. It differs from *D. dcois* in the nearly parallel sides of the glabella, the absence of glabellar furrows, and very short, almost flat frontal limb. The occipital lobe is nearly one-half the length of the head.

Surface under strong magnifier smooth. The type specimen of the head has a length of 11 mm.

Formation and locality.—Middle Cambrian. Near the upper portion of the Chang Hsia formation. Two miles east of Chang Hsia, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

Genus ILLÆNURUS Hall.

ILLÆNURUS CANENS, new species.

Head, exclusive of the free cheeks, sub-rhomboidal in outline, moderately convex. Glabella sub-quadrate, moderately convex, length and width the same, without perceptible occipital or dorsal furrows; palpebral lobes small, with their anterior end opposite the center of the glabella; frontal margin broadly rounded; postero-lateral limbs short and subtriangular in outline; the facial suture, cutting the frontal rim on a line with the base of the palpebral lobe, passes directly to the anterior margin of the palpebral lobe; it encircles the latter, and then, curving gently outward, passes in an almost direct line to the posterior lateral margin of the postero-lateral limb.

Surface minutely punctate under a strong lens.

The pygidia associated with the head parts are rounded, subtriangular in outline, and about two-thirds as long as the width at the anterior margin, rather convex, and marked on the interior of the cast by a faintly defined, rather narrow axis, and very slight traces of ten or more transverse furrows on the axis, that are more faintly indicated for a short distance on the pleural lobes.

The largest head in the collection has a length of 14 mm., with the same width at the palpebral lobes; a pygidium 14 mm. in length has a width of 20 mm.

This species appears to be most nearly related to *Illænurus eurekensis*,[a] which occurs at the base of the Ordovician in the Eureka district of Nevada, but it differs in the smaller palpebral lobes, which are situated farther back on the head; and it differs from *I. ceres* in its proportionately longer head.

This species is quite widely distributed in the Upper Cambrian limestone, in association with the following trilobites: *Illænurus dictys*, *Menocephalus depressus*, *Pagodia bia*, *P. lotos*, *Psychaspis ceto*.

Formation and locality.—Upper Cambrian, lower portion of the Chao Mi Tien formation. At Chao Mi Tien; 7.5 miles east of Chao Mi Tien; at Pagoda Hill, 1 mile west southwest of Tai An Fu; and two-thirds of a mile west of Tai An Fu, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ILLÆNURUS CERES, new species.

Head, exclusive of the free cheeks, rounded subquadrate, moderately convex; the posterior margin of the head curves slightly upward opposite the glabella, where there is a slight thickening which gives the appearance of a narrow occipital ring; the front margin of the head is broadly curved. Glabella very faintly outlined on the interior of the cast; as thus shown it has a width at the base of 6 mm. and at the front of 4.5 mm. on a head 11 mm. in length; its somewhat rounded front is about 1 mm. from the frontal rim of the head; no traces of glabellar furrows have been observed, and in only one specimen can the very faint dorsal furrow that outlines the glabella be seen.

Fixed cheeks of the same specimen 3 mm. in width at the palpebral lobes, from which they extend with almost uniform width to the front, and broaden slightly backward before merging into the short, triangular postero-lateral limbs; palpebral lobes small and situated back of a line passing through the transverse center of the head.

The associated pygidium in the same fragment of rock is rounded subtriangular in outline, moderately convex, and without any indication of an axis except a very narrow, slightly marked median ridge on the cast of the interior; a specimen 11 mm. in length has a width of 16 mm. at the front margin; a very slight elevation of the front margin near the center indicates that the axial lobe of this specimen had a width of about 6 mm.

Surface minutely but not closely punctate under a strong lens.

[a] Mon. U. S. Geol. Survey, VIII, 1884, p. 97, pl. xii, figs. 4 and 4*a*.

This species differs from *I. canens* by the greater width of the head at the palpebral lobes and less convexity; the associated pygidium is less convex, more subtriangular in outline, and without the indication of a central axis.

The associated species on the same hand specimen are *Ptycaspis ceto* and *Anomocarella carme*.

Formation and locality.—Upper Cambrian, lower portion of Chao Mi Tien formation, in gray, crystalline, fossiliferous limestone; Chao Mi Tien, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

ILLÆNURUS DICTYS, new species.

Head, exclusive of the free cheeks, rounded, subquadrate, gently convex; the posterior margin of the head curves slightly upward opposite the central portion, where there is a slight elevation which gives the appearance of a narrow occipital ring; the front margin of the head is broadly rounded, with a very broad obtuse angle at the center; the cast of the interior of the crust shows a very faint, low, longitudinal median ridge. The glabella is not defined from the fixed cheeks. The palpebral lobes are small and situated nearly opposite the center of the head; postero-lateral limbs small and short.

Surface smooth under a strong lens.

The associated pygidium is transverse, rounded, subtriangular; front broadly rounded; sides gently rounded, forming a rounded obtuse angle at the posterior margin; the cast of the interior of the crust shows a narrow, slightly defined axis, with eight or more very faint transverse furrows and rings. The pleural lobes are gently convex and without any trace of furrows.

A head 6 mm. in length has an equal width at the palpebral lobes. A specimen of the associated pygidium 7 mm. in length has a width of 8 mm. at the front margin.

This species differs from *Illænurus ceres* in the obtusely pointed front margin of the head and its less convexity. From *Illænurus canens* it differs in the direction of the facial sutures from the front margin back to the palpebral lobes; the sutures of *Illænurus dictys* extend slightly outward from the base of the palpebral lobe to the margin, while those of *Illænurus canens* extend directly forward, making the central portion of the head narrower at the front margin.

Formation and locality.—Upper Cambrian. Central portion of Chao Mi Tien formation, Pagoda hill, 1 mile west and southwest of Tai An Fu, Shangtung, China.

Collected by Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

OSTRACODA.

Genus BRADORIA Matthew.

BRADORIA BERGERONI, new species.

General outline broadly semielliptical. Hinge line straight, nearly as wide as the breadth of the valve; anterior cardinal angle about 80°; posterior cardinal angle slightly obtuse; the anterior margin is very slightly curved from the angle to where it merges into the broadly rounded front; posterior margin somewhat broadly rounded from the angle to the front. Surface convex, the greatest convexity being back of the transverse center between the ocular tubercle and the posterior fourth of the valve. From this elevated portion the surface slopes rapidly and somewhat abruptly to the hinge line and more gently to the lower margin. From the anterior cardinal angle a very short, narrow ridge extends to a small, circular, slightly elevated tubercle which is situated about an equal distance from the hinge line and the anterior margin. The anterior, posterior, and lower margins have a narrow, rounded rim that is slightly flattened on the inner side.

Surface marked by shallow scattered punctæ and very fine punctæ, as seen under a strong lens.

Width of valve 1.8 mm.; length 1 mm; depth about 0.5 mm.

This species is distinguished from *B. steropa* by its greater width and the form of the ocular tubercle.

Formation and locality.—Middle Cambrian; compact, bluish-gray, thin-bedded limestones; from shingle on gravel bar in the Lan Hö, 1 mile south of Chên Ping Hsien, southeastern Shensi, China.

Collected by Bailey Willis and Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

BRADORIA ENYO, new species.

General outline irregularly oval. Hinge line about four-fifths the width of the valve. Anterior cardinal angle nearly a right angle; posterior cardinal angle slightly obtuse; the anterior margin extends from the angle almost directly downward to where it curves and merges into the broadly rounded lower margin; posterior margin very slightly rounded from the angle downward to where it curves and merges into the lower margin. Surface moderately and uniformly convex, the highest portion being near the center; a very short, narrow, low, and somewhat obscure ridge extends obliquely inward from the anterior cardinal angle to a small, slightly elevated ocular tubercle; a slight furrow appears to extend from the tubercle obliquely to a point about midway of the hinge line; a little posterior to this and near the hinge line there appears to be a minute low tubercle.

The surface appears to be minutely punctate under a strong lens.

Width of valve 1 mm.; length 0.75 mm.; depth about 0.25 mm.

This species is distinguished from *B. steropc* by the difference in the form of the anterior cardinal angle and the position of the ocular tubercle. The latter is in about the same position as the tubercle on *B. bergeroni*, but *B. bergeroni* is quite different in its outline and convexity.

Formation and locality.—Middle Cambrian; compact, bluish-gray, thin-bedded limestone; from shingle on gravel bar in the Lan Hö, 1 mile south of Chên Ping Hsien, southeastern Shensi, China.

Collected by Bailey Willis and Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

BRADORIA ERIS, new species.

General outline obliquely semicircular. Hinge line straight; anterior cardinal angle about 70°; posterior cardinal angle slightly obtuse; anterior margin nearly straight to where it merges into the rounded lower margin; posterior margin gently rounded from the angle down to where it merges into the lower margin. Surface moderately convex, with the highest point at the tubercle a little in front of the center; a very narrow rim extends from the posterior cardinal angle around to the anterior side, where it broadens out and continues to the anterior cardinal angle; a slight narrow ridge extends obliquely inward a short distance from the anterior cardinal angle to a furrow that extends from the hinge line at right angles a short distance; the ridge and furrow outline a small lobe; from the inner angle formed by the furrow and ridge described a very narrow ridge extends downward subparallel to the anterior margin to the base of a strong, elevated tubercle or spine that is situated on the anterior third a little in advance of the transverse center of the valve.

Under a strong lens the surface appears to be slightly roughened by shallow punctae.

Width, 2 mm.; length, 1.5 mm.; depth, about 0.5 mm.

This species differs from *Bradoria steropc* in the outline of its valve and the presence of an elevated tubercle near the center.

Formation and locality.—Middle Cambrian; compact, bluish-gray, thin-bedded limestone; from shingle on gravel bar in the Lan Hö, 1 mile south of Chên Ping Hsien, southeastern Shensi, China.

Collected by Bailey Willis and Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

BRADORIA FRAGILIS, new species.

Hinge line nearly straight, about one-fifth shorter than the width of the valve. Posterior cardinal angle obtuse, with the marginal curve long and passing into the broad curve of the lower end of the valve; anterior cardinal angle about 75°, with the anterior margin nearly

straight to where it merges into the broad curve of the lower part of the valve.

Surface of the valve wrinkled to such an extent that it looks like wrinkled parchment. What may be an ocular tubercle occurs a short distance from the hinge and anterior margin. Surface minutely punctate under a strong lens.

Width, 2.25 mm.; length, 2 mm.; depth unknown, as the flexible test has been compressed.

This species differs from *Aluta flexilis* Matthew[a] in having a straight hinge line; in this respect it resembles some forms of Leperditia. For the present it is referred to *Bradoria* on account of its close resemblance to *Bradoria sterope*.

Formation and locality.—The specimens were collected from a fragment of compact, bluish-gray, thin-bedded limestone, containing fragments of a trilobite that suggests *Dorypyge*. On this account the horizon is referred to the Middle Cambrian.

Collected from shingle on a gravel bar in the Lan Hö, 1 mile south of Chên Ping Hsien, southeastern Shensi, China.

Collected by Bailey Willis and Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

BRADORIA STEROPE, new species.

Outline of shell obliquely semicircular. Hinge line straight, nearly as long as the width of the valve. Anterior cardinal angle about 80°; anterior curve obsolete; from the anterior cardinal angle the margin slopes downward and slightly inward, curving gently into the broadly rounded lower margin; posterior cardinal angle slightly obtuse; posterior margin curves gently from the angle to the broad curve of the lower side of the valve, which gives a broadly rounded posterior end. The valve is rather strongly convex, rising to the greatest height near the center. The surface is marked by a very narrow rim; from the anterior cardinal angle a narrow ridge extends obliquely inward about one-half the distance toward the center, and terminates in a slight tubercle; on the anterior side there are three shallow depressions, as though the surface had been indented; on the posterior side there is one larger depression directly back of the tubercle at the end of the ridge, and a slight depression in the angle formed by the ocular ridge, the hinge line, and the ridge between the two depressions.

Surface with minute scattered punctæ, as seen under a strong lens.

The valve has a width of 1.125 mm.; length, 0.8 mm.; depth, about 0.25 mm.

In outline this species resembles *Bradoria fragilis;* it differs in its stronger shell and distinctly marked ridge and ocular tubercle.

[a] Trans. N. Y. Acad. Sci., XV, 1896, p. 198.

Formation and locality.—Middle Cambrian; compact, bluish-gray, thin-bedded limestone; shingle on gravel bar in the Lan Hö, 1 mile south of Chên Ping Hsien, southeastern Shensi, China.

Collected by Bailey Willis and Eliot Blackwelder, of the Carnegie Institution of Washington Expedition to China.

BRADORIA WOODI, new species.

Outline of shell obliquely semicircular. Hinge line straight, a little shorter than the greatest width of the shell. Anterior cardinal angle about 70°; posterior cardinal angle obtuse. Posterior margin has a gentle curvature from the angle, which gives it a broadly rounded outline down to where it merges into the broadly rounded lower side; anterior margin almost straight and then gently curving into the lower margin. Surface rather convex, with the highest portion at the ridge around the central depression. The outer rim is very narrow and slightly rounded. From the anterior cardinal angle a narrow, sharp ridge extends obliquely inward and forward to a little below the center and arches around a rather large, depressed central space, terminating a short distance before completing a circuit of the space; between the ridge described and the hinge line are two spaces outlined by the main ridge; of these the one nearest the anterior cardinal angle is somewhat depressed and outlined by a shallow furrow extending at right angles to the hinge line from the ridge to the hinge line. At a point about two-thirds the distance of the length of the hinge line a short and very slight ridge extends toward the hinge line from the main ridge; between this and the slight furrow there is a slightly convex area. Two minute tubercles occur on the long central ridge, one at the point where it begins the loop to inclose the depressed central space, and the other on the opposite side of the depressed space.

Surface minutely punctate under a strong lens.

Entire width of valve 2 mm.; length 1.25 mm.; depth about 0.5 mm.

This species is distinguished from *Bradoria sterope* by its wider valve and the presence of the central ridge and depressed space.

The specific name is given in recognition of the most excellent and thorough preparatory work that was done by Miss Elvira Wood in the preliminary study of the Cambrian fossils from China and her work upon the Devonian crinoids.

Formation and locality.—Middle Cambrian; compact, bluish-gray, thin-bedded limestone; from shingle on gravel bar in the Lan Hö, 1 mile southeast of Chên Ping Hsien, southeastern Shensi, China.

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