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Charles D. and Mary Vaux Walcott
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NEW LOWER CAMBRIAN TRILOBITE
FAUNULE FROM THE TACONIC
SEQUENCE OF NEW YORK

(WITH 12 PLATES)

By
FRANCO RASETTI

Johns Hopkins University, Baltimore, Md.
Honorary Research Associate, Smithsonian Institution



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(PUBLICATION 4662)

CITY OF WASHINGTON
PUBLISHED BY THE SMITHSONIAN INSTITUTION
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INTRODUCTION AND ACKNOWLEDGMENTS

THE LOWER CAMBRIAN formations of the Taconic sequence in New York are among the most thoroughly investigated deposits of this age in eastern North America. After the classic faunal studies of Ford and Walcott in the second half of the last century, no essentially new faunules were discovered. Lochman (1956) described several new species and gave a general review of the known Lower Cambrian fossils of the sequence, occurring in what was formerly known as the Schodack Formation, now subdivided (Zen, 1964) into several units. All the species may be considered members of a single assemblage, named from the characteristic olenellid trilobite *Elliptocephala asaphoides*.

The discovery of an essentially new Lower Cambrian trilobite faunule was therefore unexpected. In 1956 Mr. Thomas W. Talmadge noticed the presence of fossiliferous limestone outcrops on a hill south of North Chatham, Columbia County. In 1963 Dr. John M. Bird collected small samples from two of these outcrops and submitted them to the U.S. Geological Survey for identification of the fossils. Dr. A. R. Palmer prepared and examined the specimens and recognized in one of the collections the presence of trilobites unlike any of those previously known from the Lower Cambrian of the Taconic sequence or any other region. He suggested to the writer a study of the new faunule. Collections much larger than the original ones were made by Dr. Bird and the writer, until most of the accessible, fossiliferous portions of the limestone outcrop had been recovered and examined. Hundreds of trilobite specimens, represent-

ing about 30 species, largely new and belonging to new genera, form the object of the present study.

The writer is indebted to the American Philosophical Society for grant No. 3454-P which defrayed field and laboratory expenses. He thankfully acknowledges the enthusiastic cooperation of Dr. John M. Bird in quarrying the limestone and searching for other fossiliferous localities. Thanks are also due to Dr. A. R. Palmer for suggesting this study and for valuable discussions on Cambrian faunas; to Mr. Thomas W. Talmadge for information on the results of his stratigraphic studies in the East Chatham quadrangle and for accompanying the writer on a field excursion; to Dr. George Theokritoff for information on an undescribed Lower Cambrian faunule from Washington County, New York; to Dr. E-an Zen for discussions on the Taconic sequence; and to Mr. A. W. A. Rushton of the British Geological Survey for communicating specimens and photographs of an undescribed faunule from England which shows interesting affinities with the one described herein.

OCCURRENCE AND PRESERVATION OF THE FOSSILS

The Cambrian strata in the northwestern quarter of the East Chatham 7½-minute quadrangle are notable for the development of regularly bedded limestone units, an unusual feature in the Cambrian of the Taconic sequence in Columbia and Rensselaer Counties, New York, where fossiliferous limestone generally occurs only in conglomerates. Among the localities where such limestone beds form outcrops is a hill (Griswold farm) about 1 mile southeast of North Chatham, Columbia County. The summit of the hill is a plateau where limestone beds interstratified with black shale form scattered outcrops. The beds strike north-south and dip steeply (50°-60°) east. All the fossils described herein (with the exception of one species from Quebec, Canada) were recovered from a limestone bed traceable through intermittent outcrops over a distance of several hundred feet. Even though fossils of the same faunule were observed at several places along this bed, only one block of limestone, about 1 foot thick, 5 feet long, excavated to a depth of 3 feet, supplied all the described fossils, the remainder of the limestone usually being too fine-grained to yield fossils. About 400 pounds of rock were removed and examined. The limestone is dark-gray, finely granular to aphanitic, in some portions the bedding being clearly marked by layers of more abundant insoluble material or fossil fragments, else-

where indistinct. Most of the fossils were concentrated in small pockets.

The fossiliferous outcrop is located 27 mm from the west edge and 164 mm from the north edge of the East Chatham 7½-minute USGS quadrangle, scale 1 : 24,000 (USGS collections 3810, 4216; writer's collection cs-4). The faunule from this bed is referred to hereafter as the *Acimetopus bilobatus* faunule from one of the most common and characteristic trilobites.

The most common fossils are small inarticulate brachiopods, especially an acrotretid and less abundant linguloid forms. Trilobites are also copious in some portions of the rock, but most of the specimens are too fragmentary for identification. Evidently the tests were transported by currents for considerable time and distance before being covered by the sediment. All the trilobites are dismembered, except one cephalon with two thoracic segments attached. Nevertheless, many of the compact eodiscid cephalae and pygidia did not suffer excessive damage. In exposing the fossils, the matrix invariably separates at the boundary of the outer surface of the test, hence ornamentation is well preserved. Some of the specimens suffered slight flattening or fracturing in the slumping or compaction of the sediment. Distortion due to tectonic deformation of the rock is present to a slight degree in some of the material.

The size of the trilobites presents an unusual situation. The Eodiscids are, on the average, large for the family. Examples of *Litometopus longispinus* indicate that the species attained a length of 50 mm, almost gigantic for an Eodiscid. Most of the examples are much smaller, but very small, immature specimens seem to be lacking, cephalae or pygidia below 3 or 4 mm in length being rare. All the Olenellids on the contrary are of small size, fairly complete cephalae not exceeding 4-5 mm in length. It seems difficult to attribute this fact to the delicate nature of the olenellid tests and their consequent fragmentation, since no fragments indicating individuals of medium or large sizes were observed. In the well-known conglomeratic limestones at Schodack Landing and Troy, even though the trilobite tests are excessively fragmentary and no large cephalae have been recovered, the presence of adult examples of *Elliptocephala asaphoides* is proved by the frequent occurrence of fragments of their large pleurae. Nor can the lack of very small Eodiscids and large Olenellids be attributed entirely to sorting by current action, since very small brachiopods and relatively large Eodiscids are rather common.

AGE AND CHARACTER OF THE FAUNULE

The present information is insufficient to determine the precise relative age of the new faunule with respect to other known Lower Cambrian faunules of North America, and in particular of the Taconic sequence. The scanty stratigraphic evidence that might supply such information is summarized below.

Other fossiliferous strata form outcrops east of the bed yielding the *Acimetopus* faunule, and a greater variety of Cambrian fossils was obtained from limestone blocks in the surrounding stone walls, partly derived from beds not presently exposed. The next bed to the east, 45 feet higher stratigraphically than the *Acimetopus* stratum (under the unconfirmed assumptions that the intervening beds form an orderly stratigraphic succession and that the strata are not inverted), yielded a *Pagetides* faunule, also collected at several other localities in the northeastern quarter of the East Chatham quadrangle. *Pagetides elegans* and another species of the genus are by far the most common identifiable fossils in this faunule; Olenellid fragments, *Bonia* and *Prozacanthoides* have been observed. The third fossiliferous limestone bed, which under the above assumptions would be about 450 feet higher stratigraphically than the *Acimetopus* bed, yielded *Pagetia* and *Peronopsis*, almost certainly indicative of the Middle Cambrian. Trilobites of the typical *Elliptocephala asaphoides* assemblage, such as *Elliptocephala* itself, *Calodiscus lobatus*, or *Serrodiscus speciosus*, have never been seen at the locality, either in outcrops or loose blocks; they are known in the East Chatham quadrangle only from the exposures of the Ashley Hill Conglomerate (Dale, 1904; Zen, 1964) whose type locality lies in the northeastern quarter of the quadrangle.

The structure of the area is exceedingly complicated, as may be observed, for example, in a deep cut on the road from North Chatham to Malden Bridge, which exposes a considerable thickness of limestone beds interstratified with black shale. The strata appear closely folded, causing some intervals to be repeated in reverse order, even though the dip seems to remain fairly constant. It would be difficult to discern such structures from scattered outcrops as observed at the *Acimetopus* locality, where one might readily be misled to infer an orderly succession. Limestone beds in the road cut yielded a *Pagetides* faunule, hence they may be equivalent to a portion of the section on the Griswold farm. For these reasons, the succession of faunules outlined above, i.e., in ascending order the *Acimetopus*, *Pagetides*, and *Pagetia-Peronopsis* faunules, is only suggested as tentative. Talmadge (private communication) from purely strati-

graphic and structural evidence had previously reached the conclusion that by and large the strata on the Griswold farm become progressively younger toward the east, which would confirm the suggested order. He also considers all these strata higher than the Ashley Hill Conglomerate. Since the latter holds the *Elliptocephala* fauna not only in boulders, but also in a regularly bedded limestone interval at the base of the conglomerate, one might conclude that the latter fauna is older than the *Acimetopus* and *Pagetides* faunules.

The *Elliptocephala asaphoides* assemblage extends through a considerable thickness of strata in Washington County (Lochman, 1956; Theokritoff, 1964). It is possible that the difference between the *Acimetopus bilobatus* faunule and that assemblage is one of environment rather than age. A faunule reported by Theokritoff (1964) from Washington County, believed to be somewhat younger than the typical *Elliptocephala asaphoides* assemblage, shows no particular resemblance to the one described herein.

The *Acimetopus bilobatus* faunule is notable for the number and variety of trilobites of the family Eodiscidae, of which 9 new genera, 20 new named species, and an unnamed one are described herein, all based on cephalae. A few unassigned pygidia, in part possibly representing additional species, are also described. None of the Eodiscidae can be referred to previously known species, even though several are referable to the well-known genera *Calodiscus* and *Serrodiscus*.

The Olenellidae are represented by numerous fragments of small individuals, referable to three species, none of which is the common *Elliptocephala asaphoides* known from numerous localities in the Taconic sequence of Washington, Rensselaer, and Columbia Counties. Immature Olenellid cephalae cannot be specifically identified by comparison with adult individuals, and even the generic reference may remain doubtful, since several of the genera were based on the features of the entire exoskeleton. Two of the species are tentatively referred to *Paedeumias* and one to *Olenellus*; none shows close resemblance to named species.

The opisthoparian trilobites are represented by four undetermined species of *Bonnia*, a pygidium referred to *Kootenia*, and a peculiar pygidium belonging to an undescribed genus of uncertain affinities.

Conspicuously absent from the *Acimetopus bilobatus* faunule are Eodiscids with eyes and facial sutures, which constitute the family Pagetiidae, even though species of *Pagetides* are the most common trilobites in the nearest fossiliferous outcrop. Also totally absent are

the ptychoparioid trilobites, so common in the late Lower Cambrian deposits of the Appalachian and Cordilleran provinces. No fragments referable to the Agnostids were observed.

Even though the *Acimetopus bilobatus* faunule has few, if any, species in common with the *Elliptocephala asaphoides* assemblage, the latter is still the Lower Cambrian fauna of North America which it resembles most closely. Possibly all the species, and many of the genera, are different, but the same families are represented, approximately in the same relative abundance: the Eodiscidae and Olenellidae are common, *Bonnia* and *Kootenia* are rare in both cases. The *Acimetopus bilobatus* faunule shows far less affinity with the late Lower Cambrian fauna of the Pacific province (cratonic facies of Lochman and Wilson, 1958), which is characterized by the abundance of Ptychoparioids and *Bonnia*, frequently includes *Kootenia*, *Protypus*, and *Prozacanthoides*, and also *Pagetia* and *Pagetides*. The resemblance is not very close either with the typical late Lower Cambrian fauna of the Acado-Baltic province (eugeosynclinal facies of Lochman and Wilson), chiefly characterized by the Protolenidae, where the Eodiscids are represented both by oculate (*Hebediscus*), and blind genera (*Calodiscus*, *Cobboldites*, *Serrodiscus*). In North America faunules of this type are known from Massachusetts and eastern Newfoundland (Hutchinson, 1962). The evidence favors the reference of the new faunule, like the *Elliptocephala asaphoides* assemblage, to an "intermediate realm" (Lochman and Wilson, 1958) between the cratonic and eugeosynclinal sedimentary provinces.

Through the courtesy of Mr. A. W. A. Rushton, the writer was able to examine specimens and photographs of a remarkable new faunule discovered in the Purley Shales of Warwickshire, England. The faunule includes several new species of Eodiscidae, of which two belong to new genera, one is a *Serrodiscus* remarkably similar to *Serrodiscus subclavatus* described herein, and another is definitely referable to *Acidiscus*, closely resembling *Acidiscus hexacanthus* in possessing two pairs of marginal cephalic spines. The Eodiscidae in the Purley Shales are associated with *Ellipsostrenua* and *Condylopyge*. Even though all the previously described species of this agnostid genus occur in the Middle Cambrian, the remainder of the faunule is suggestive of a late Lower Cambrian age. A fairly close time equivalence of the two faunules may be indicated by the presence of closely related Eodiscidae.

SYSTEMATIC DESCRIPTIONS

GENERAL STATEMENT

All the fossils described herein were deposited in the U.S. National Museum collections, excepting one specimen from Quebec which is in the collections of the Geological Survey of Canada.

All the illustrations show the outer surface of the test.

The abbreviations (tr.) for transverse, (sag.) for sagittal, and (exsag.) for exsagittal qualify such terms as "wide," "short," etc., whenever the direction of the measurement might otherwise be misinterpreted.

Family EODISCIDAE Raymond, 1913

The Eodiscidae are the most numerous and interesting of the trilobites described herein, as they show a greater variety of forms than the genera previously known. Hence the characters observed in the different parts of the exoskeleton are briefly discussed.

All the species described herein are represented by separate cephalae and pygidia; hence the number of thoracic segments is unknown.

Owing to the large number of species occurring in the same bed, matching of cephalae and pygidia presented a problem. In several cases assignments with varying degree of probability could be made. Criteria for associating cephalae and pygidia that were used are general shape, size, surface ornamentation, and frequency of occurrence. It is unlikely that the collection contains a pygidium for every cephalon or vice versa. To avoid the risk of nomenclatural confusion, no taxa were based on pygidia; those pygidia that could not be assigned to cephalae are described and illustrated but not named.

Features of the various parts of the exoskeleton are discussed below.

Glabella.—The glabella shows considerable variety of form. It may be tapered as in *Bolboparia*, where it is short in proportion to the length of the cephalon; more or less parallel-sided as in most of the species; or even somewhat expanded toward the front as in *Serrodiscus subclavatus* and *Bathydiscus dolichometopus*. Lateral furrows are usually short and shallow or absent. However, in *Acimetopus*, *Analox*, and some species of *Calodiscus*, the glabella is divided by a deep transverse furrow into an anterior and a posterior lobe. A tendency in this direction had been observed, for example, in *Calodiscus lobatus* and its form *agnostoides* (Lochman, 1956), in *C. helena*, *C. meeki*, and even in *Serrodiscus speciosus* (Rasetti, 1952).

In these cases there may even be two shallow furrows across the glabella. The sharp and deep transglabellar furrow of *Acimetopus bilobatus* and *Calodiscus reticulatus*, and the somewhat shallower one of *Analox bipunctata*, seem to represent more advanced stages of this type of glabellar lobation. A sharp transverse furrow was previously known in *Opsidiscus bilobatus* (Westergard, 1946) and *Tannudiscus tannuolaicus* (Pokrovskaya, 1959). It is not clear whether the transglabellar furrow in these Eodiscids, and the possibly homologous furrow in the Agnostids, result from modification of one of the pairs of glabellar furrows, or are independent of them, representing a secondary segmentation. The doubt is suggested by the probable secondary nature of the segmentation of the pygidial axis in the Agnostids (Palmer, 1955).

In *Acimetopus* the glabellar lobation is the most specialized of any described Eodiscid, the broad transglabellar furrow possessing a pair of small, rounded lobes at the sides.

In *Stigmatiscus*, and to a lesser extent in *Acidiscus*, the two pairs of lateral glabellar furrows assume the form of short, fairly deep pits, a feature unusual in the family even though it occurs in other groups of trilobites.

Another unusual character for the Eodiscids is the extension of the posterior portion of the glabella into an upright spine, observed in *Acidiscus*, *Acimetopus*, and *Bolboparia*. In *Acidiscus* there is, in addition, an occipital spine, whereas in *Acimetopus* and *Bolboparia* the occipital ring is short and simple.

Cephalic border.—A definite border furrow and border around the cephalon are present in all genera excepting *Analox* where the lateral border is missing, although an anterior border of triangular shape and the posterior border are well developed. One of the striking features of the border in several of the new genera is the development of marginal spines at various positions.

One pair of short, lateral marginal spines is observed in *Acimetopus*, *Bolboparia*, *Litometopus*, and *Acidiscus birdi*. Two pairs are present in *Acidiscus hexacanthus* and *Oodiscus subgranulatus*. As the spines vary in position, it is questionable whether they can be homologized among the different species.

The posterior cephalic border shows variable features that can not be readily homologized among the different genera. In many of the species it bears a pair of spines, which may vary in position from less than halfway from the axial furrow to the genal angle (in *Oodiscus*, *Bathydiscus*, and *Stigmatiscus stenometopus*) to the proximity of the genal angle as in *Serrodiscus subclavatus*, *Acimetopus biloba-*

tus, *Bolboparia superba*, *Acidiscus birdi*, *Litometopus longispinus*, and *Stigmatiscus gibbosus*. Presumably the spine should be considered homologous in all these genera, but there are no decisive arguments in favor of this assumption. In *Oodiscus* and *Bathydiscus* the base of the spine coincides with the position of a sharp geniculation, the portion of the posterior border distal to this point being sharply bent downward and somewhat forward. In *Litometopus longispinus* and, to a lesser extent, in *Serrodiscus subclavatus*, the posterior border presents an unusual feature consisting of a narrow ridge separated from the main part of the border by a short, transverse furrow. The distal end of this ridge produces a slight rearward projection of the posterior margin. In one specimen of *Serrodiscus subclavatus* preserving two thoracic segments attached to the cephalon, the ridge on the cephalic margin is seen to correspond to the fulcrum on the anterior margin of the first thoracic segment. A similar feature is present at the articulation between the first and second thoracic segments. In *Litometopus longispinus* the tooth on the posterior cephalic border is more conspicuous. In both species the "genal" spine is located more distally than these features.

Pygidium.—The pygidia present less variety than the cephalae. The axis is always well defined except in one unassigned pygidium where the axial furrow is barely indicated. In *Acimetopus* and *Bolboparia* there is a large, upright spine on the second axial ring. In *Serrodiscus subclavatus* there is a long spine on the posterior part of the unsegmented axis. In *Acidiscus* there are spines on several of the axial rings. Border furrow and border are well differentiated in all pygidia. A well-developed articulating facet is present in all genera; this is the most obvious feature for distinguishing pygidia from cephalae in doubtful cases. Marginal spines, sometimes visible from above, more often appearing as extensions of the doublure and hence ventral in position, may be present. In most species the doublure is reflexed as usual in trilobite pygidia. However, in *Analox bipunctata* and the pygidium attributed to *Bathydiscus dolichometopus*, the pygidial doublure forms an almost vertical face rather than being reflexed inward to parallel the dorsal exoskeleton. In neither species this feature is present in the cephalon, where the doublure appears to be narrow and not sharply defined, the dorsal test being gradually downrolled.

Ornamentation.—The outer surface of the test may be smooth, punctate, finely granulate, coarsely granulate with granules of one size (*Acimetopus*) or different sizes (*Bolboparia*). The larger of these granules seem broken at the tip and may represent the bases

of short spines. *Calodiscus reticulatus* has a strong reticulate ornamentation.

Classification.—The Eodiscidae of North America have so far been referred to five genera (Rasetti, 1952): *Calodiscus* Howell, 1935 (type species, *Agnostus lobatus* Hall); *Dawsonia* Hartt in Dawson, 1868 (type species, *Microdiscus dawsoni* Hartt in Dawson); *Eodiscus* Hartt in Walcott, 1884 (type species, *Eodiscus pulchellus* Hartt in Walcott=*Microdiscus scanicus* Linnarsson); *Serrodiscus* R. and E. Richter (type species, *Eodiscus (Serrodiscus) serratus* R. and E. Richter); and *Weymouthia* Raymond, 1913 (type species, *Agnostus? nobilis* Ford). Of these five North American Eodiscid genera, *Dawsonia* and *Eodiscus* occur exclusively in the Middle Cambrian *Paradoxides* beds; the other genera are Lower Cambrian.

Genera that have been proposed for Eodiscidae from Europe and Asia are *Cobboldites* Kobayashi, 1943 (type species, *Microdiscus comleyensis* Cobbold); *Metadiscus* Kobayashi, 1943 (type species, *Microdiscus sculptus* Hicks); *Ladadiscus* Pokrovskaya, 1959 (type species, *Ladadiscus limbatus* Pokrovskaya). To these genera the writer would add *Tannudiscus* Pokrovskaya, 1959 (type species, *Tannudiscus tannuolaicus* Pokrovskaya), originally assigned to the family Opsidiscidae (Pokrovskaya, 1959), which seems of questionable validity since *Opsidiscus*, which has vestigial eyes but no facial sutures, could be referred either to the Pagetiidae or the Eodiscidae, the presence of a transglabellar furrow having little significance. *Tannudiscus* has no trace of eyes and should be placed in the Eodiscidae even if a separate family Opsidiscidae were recognized.

The nine new genera described herein approximately double the size of the family and it was considered whether the additional knowledge suggested some grouping of the genera that would indicate evolutionary trends. On the basis of present knowledge there seems to be no basis for a meaningful arrangement of the genera. The glabellar lobation, which in general is one of the important taxonomic features in trilobites, seems of little significance, as shown by the gradual transition from generalized lobation to the specialized lobation where all furrows have disappeared but for a deep, straight transglabellar furrow (*Calodiscus reticulatus*). Other characters, such as shape and relative length of the glabella, cephalic border furrow and border, glabellar, occipital and marginal cephalic spines, ornamentation, etc., seem even less significant, as also are believed to be the pygidial features. Even an arrangement of the genera based on characters of little evolutionary and taxonomic significance would

be difficult to carry out because genera that are alike in one feature are apt to be strikingly different in one or several others. For this reason the genera are described herein in alphabetical order.

ACIDISCUS Rasetti, new genus

Description.—Cephalon of moderate convexity, semielliptical. Glabella not reaching the anterior border, subcylindrical, with two short, somewhat pit-like pairs of lateral furrows, in the two known species possessing a small upright spine on its posterior portion. Occipital furrow wide; occipital ring well defined, bearing a spine. Posterior border straight from the axial furrow to the base of the genal spine. Lateral cephalic border with one or two pairs of marginal spines.

Pygidium with long, multisegmented axis. Geniculation situated rather distally; facet well developed. Pleural regions unfurrowed; border and border furrow well developed, of average width. Surface smooth or with weak ornamentation. The narrow doublure may be extended into short spines.

Type species.—*Acidiscus birdi* Rasetti, new species.

Occurrence.—Late Lower Cambrian of New York. Also in the Purley Shales of Warwickshire, England (Rushton, private communication).

Discussion.—This genus is obviously a close relative of *Serrodiscus*. The pygidium is much the same as in that genus. The cephalon, however, has important distinctive features, the most significant being the development of glabellar and occipital furrows. Another distinctive character is the tendency to develop spines on the glabella, occipital ring, at the genal angle, and on the cephalic border. The glabellar furrows also indicate relationship to *Stigmatiscus*; in several features *Acidiscus* may be considered transitional between the latter genus and *Serrodiscus*.

ACIDISCUS BIRDI Rasetti, new species

Plate 1, figure 2; plate 6, figures 11-19

Available material.—Numerous cephalata and pygidia, of which a few are fairly complete.

Description.—Cephalon semielliptical. Glabella rising well above the cheeks, very convex transversely, tapered in anteriormost portion, narrowly rounded in front, occupying with occipital ring more than two-thirds of cephalic length. Two pairs of distinct, short,

somewhat pit-like lateral furrows; the posterior pair longer, directed backward almost to meet occipital furrow, hence defining small, elongate-triangular basal lobes. The glabella reaches maximum elevation near the posterior end, at the level of the posterior pair of lateral furrows, where it possesses a small upright spine. Occipital furrow deepened into a pair of small pits laterally, wide medially; occipital ring of moderate length (sag.), extended into a spine incomplete in all specimens. Cheeks convex, not separated medially by a preglabellar depression, sloping steeply to border furrow in posterior portion. Border lying in a plane, slightly convex, widest medially, narrowing toward the genal angles, possessing a pair of small lateral spines anterior to the level of the front end of the glabella. A series of five or six pairs of low tubercles, as usual in species of *Serrodiscus*, is visible on the lateral border. The posterior border furrow is directed outward and slightly forward from the axial furrow, thus forming an angle with the posterior cephalic margin and giving the posterior border an elongate-triangular shape. Posterior cephalic margin straight from axial furrow to base of short, outward-directed genal spine.

Pygidium similar to cephalon in general shape, somewhat more distinctly subtriangular. Axis narrow and long, barely failing to reach the posterior border furrow, fully segmented for the entire length, composed of 12 rings including the terminal one. There is a short, upright spine on each of the first seven axial rings. Pleural regions convex, totally unfurrowed. Border furrow deep, border relatively narrow, of almost even width. Articulating facet well developed. Border extended downward and inward into narrow doublure forming a series of blunt spines not visible except by removing the matrix under the border; terrace lines on doublure following the serrated outline.

Surface of test mostly smooth, except for granules visible in some specimens on the last few axial rings and sometimes on the posterior-most portion of the pleural regions. Length of largest (incomplete) cephalon 18 mm, width 20 mm. Length of largest pygidium 12 mm, width 16 mm.

The species is named for Dr. John M. Bird who collected the holotype.

Occurrence.—Collection cs-4, North Chatham.

Types.—Holotype: U.S.N.M. 145987. Paratypes: U.S.N.M. 145988.

ACIDISCUS HEXACANTHUS Rasetti, new species

Plate 7, figures 1-6

Available material.—Two cephala and one pygidium.

Description.—It is sufficient to point out the differences from the type species. Shape and convexity of cephalon and pygidium the same as in *A. birdi*. Glabella and occipital ring, including the spines, almost identical. Cephalic border bearing, in addition to an anterior pair of spines as in *A. birdi*, a second pair halfway between the first pair and the genal angle. Posterior cephalic border and genal spine as in preceding species. Lateral border lacking tubercles.

Pygidium (referred to the species on account of the ornamentation) with entirely segmented axis, also showing 12 rings including the terminal section. Axial spines developed on the first six instead of seven rings. The character of the pygidial doublure has not been ascertained.

Surface of cheeks and pleural regions of pygidium covered with small, sparse, but sharply elevated granules. The ornamentation is less marked in the holotype cephalon than in the paratype cephalon and pygidium. Similar individual variations in the identical type of ornamentation were observed in *Oodiscus subgranulatus*.

Occurrence.—Collection cs-4, North Chatham.

Types.—Holotype: U.S.N.M. 145989. Paratypes: U.S.N.M. 145990.

ACIMETOPUS Rasetti, new genus

Description.—Cephalon and pygidium strongly convex. Glabella divided by a deep, wide transglabellar depression into anterior and posterior lobes. Anterior lobe bulbous, not reaching the anterior border. Transglabellar depression subdivided laterally into two pairs of furrows, isolating a pair of small lobes; these furrows are confluent medially into one broad furrow. Posterior glabellar lobe strongly elevated and extended into a long, uptilted spine. Occipital ring short (sag.), well defined by occipital furrow, not spinose, partly concealed in dorsal view by the rearward extension of the glabella. Cheeks strongly convex, confluent anteriorly without any trace of a preglabellar depression, in their posterior portion overhanging the border furrow. Border well developed, defined by a deep border furrow, approximately lying in a plane, wide anteriorly, tapering toward the genal angle, extended into a pair of small lateral spines. Near the genal angle the lateral border furrow is confluent with the deep posterior border furrow; the border at this point is greatly reduced.

The posterior cephalic margin is straight, lacking geniculation, and extends into a short, outward-directed genal spine.

Pygidium with strongly elevated axis, furrowed for entire length and showing in type species nine segments; axis almost reaching the border, possessing a strong upright spine on the second ring. Pleural regions strongly convex and steeply downsloping; border furrow deep, border of even width, lacking spines. Surface strongly granulate.

Type species.—*Acimetopus bilobatus* Rasetti, new species.

Occurrence.—Late Lower Cambrian of New York.

Discussion.—The genus is characterized by the glabella deeply divided into anterior and posterior lobes, a feature present in some forms of *Calodiscus*, and also well developed in *Analox*. However, *Acimetopus* is unique in the development of the extra pair of small lateral lobes in the transglabellar depression.

ACIMETOPUS BILOBATUS Rasetti, new species

Plate 2, figure 3; plate 4, figures 1-14

Available material.—Numerous, well-preserved cephalia and pygidia. The assignment of the two shields to one species is unquestionable because of the unique ornamentation among the members of the faunule.

Description.—Features indicated in the generic description are not mentioned. The anterior glabellar lobe is exceedingly convex, falling vertically to the preglabellar field, moderately rounded anteriorly and slightly wider than the posterior lobe; the latter is more nearly straight-sided. The glabellar spine varies somewhat in size and attitude among the specimens; on the average it is directed upward at an angle about 30° and is sharply pointed. The border spines are situated somewhat in advance of the midpoint of the anterior glabellar lobe and are short and rapidly tapered.

The pygidial axis is deeply furrowed for the entire length, the furrows being deeper laterally. The second segment has a strong, long upright spine whose base somewhat encroaches on the adjacent ring furrows; it was not possible in any case to extract the entire spine from the matrix. The pleural regions are so convex that they somewhat overhang the border furrow, which is deep and wide. Border convex, relatively narrow.

Entire surface covered with large, elevated granules of one size. Length of largest cephalon, exclusive of glabellar spine, 9.5 mm, width 10 mm. Length of largest pygidium 7.5 mm, width 7 mm.

Occurrence.—Collection cs-4, North Chatham.

Types.—Holotype: U.S.N.M. 145991. Paratypes: U.S.N.M. 145992.

ANALOX Rasetti, new genus

Description.—Cephalon of moderate overall convexity, well rounded, somewhat narrowing toward the front. Glabella terminating in the merged axial and border furrows, divided into posterior and anterior lobes by a wide, moderately deep transglabellar furrow; no other furrows present. Posterior glabellar lobe strongly elevated and extended backward into a broad spine. Occipital ring short, barely differentiated under the rearward extension of the glabella. Anterior border swollen medially, defined by a pair of furrows directed outward and forward from the anterior angles of the glabella, not reaching the cephalic margin but ending abruptly in a pair of pits. Lateral border absent; cephalic margin in this portion downrolled into the doublure. Posterior border furrow and border well developed; geniculation distally located; genal spine absent. Border furrow extended for a short distance forward from the genal angle and then fading out.

Pygidium about equally wide and long, rather strongly convex; posterior outline regularly rounded. Axis relatively narrow, defined by a narrow but deep axial furrow, not greatly raised above the general convexity, in type species showing seven rings plus a terminal section, lacking nodes or spines. Border present but exceedingly narrow, defined by an equally narrow border furrow. Doublure forming a vertical face, not extended into spines.

Type species.—*Analox bipunctata* Rasetti, new species.

Occurrence.—Late Lower Cambrian of New York.

Discussion.—The glabella with its transglabellar furrow is like certain forms herein attributed to *Calodiscus*. The unique feature of the genus is the lack of a lateral cephalic border. The pygidium in dorsal view resembles the pygidia of *Pagetides*, but has the unusual vertical doublure.

ANALOX BIPUNCTATA Rasetti, new species

Plate 2, figure 2; plate 6, figures 1-10

Available material.—Numerous, well-preserved cephalia and pygidia. This is one of the more common species of the *Acimetopus bilobatus* faunule.

Description.—Most of the features were indicated in the generic diagnosis. Glabella defined by a broad, fairly deep axial furrow;

anterior glabellar lobe barely rising above the cheeks; posterior lobe extended into a broad spine tilted at about 30° ; the spine appears to be bluntly terminated, although this portion is not well preserved in any of the cephala. The cephalic margin lies approximately in a plane. The pygidial axis has rings well defined by straight ring furrows becoming gradually shallower toward the rear, deeper medially, and shallower near the axial furrows. The axis does not reach the posterior border, although it appears almost to do so in dorsal view on account of the strongly downsloping marginal portions of the pleural regions. The excessively narrow lateral border furrow and border maintain an almost even width throughout. The anterior border furrow instead is relatively wide; the anterior pygidial margin has a straight transverse course from the axial furrow to the geniculation, which is closer to the lateral margin than to the axial furrow. The facet is well developed.

The surface of the test is finely punctate, this ornamentation both in the cephalon and pygidium being more marked on the pleural than the axial parts. Length of the larger cephala, exclusive of glabellar spine, 4 mm, width 5 mm. Length of largest pygidium 3.5 mm, width 4 mm.

Occurrence.—Collection cs-4, North Chatham.

Types.—Holotype: U.S.N.M. 145093. Paratypes: U.S.N.M. 145094.

BATHYDISCUS Rasetti, new genus

Description.—Cephalon with considerable relief. Glabella with almost undifferentiated occipital ring prominent, slightly expanded forward, reaching the anterior border, unfurrowed. Cheeks convex and downsloping. Border convex, wide, well defined by a border furrow inbent on either side of the anterior portion of the glabella to merge with the axial furrow. In anterior view, the medial portion of the border is seen to be slightly arched, instead of lying in a plane as in most Eodiscids. Posterior cephalic border with sharp geniculation and short, erect spine located close to axial furrow as in *Oodiscus*. Surface of test smooth.

Pygidium tentatively assigned to the type species with long, well-defined, unfurrowed axis not reaching the border furrow. Border furrow narrow laterally, widened posteriorly; border narrow, slightly elevated. Doublure not reflexed to parallel the dorsal exoskeleton as in most Eodiscids, but almost vertical, with a slight inward slope, wide everywhere except in the posteriormost portion. This attitude of the doublure gives the pygidium as a whole an unusual depth.

Type species.—*Bathydiscus dolichometopus* Rasetti, new species.

Occurrence.—Late Lower Cambrian of New York.

Discussion.—The cephalon indicates close relationship to *Oodiscus* as evidenced by the same general shape, characters of glabella and occipital ring, position of the geniculation and spine on the posterior border. The chief difference is the extension of the glabella encroaching upon the anterior border furrow and the peculiar inbend of the latter at the sides. Another important feature is the arched anterior border, which does not occur in *Oodiscus*. If the pygidium is correctly assigned, its peculiar doublure represents one of the most characteristic features of the genus.

BATHYDISCUS DOLICHOMETOPUS Rasetti, new species

Plate 1, figure 3; plate 9, figures 1-16

Available material.—Several cephalata and about an equal number of pygidia.

Description.—Cephalon highly convex, semielliptical, well rounded in front. Glabella strongly elevated, slightly pear-shaped, well rounded in front, totally unfurrowed. Occipital furrow very shallow at the sides, obsolete medially; occipital ring very short, continuing the longitudinal profile of the glabella, extended farther backward than the cheeks. Cheeks very convex, laterally sloping down vertically to the border furrow. Border furrow well impressed, laterally paralleling the cephalic margin, anteriorly inbent at each side to merge with the axial furrow that separates the front of the glabella from the border. Border convex, wide, lacking tubercles. Cephalic doublure very narrow, normally reflexed. Border in anterior view arched medially, paralleled by the border furrow which rises on each side to meet the axial furrow. The pygidium is referred to the species chiefly on account of the position of the geniculation and the fit of the up-arched anterior border of the cephalon and down-arched posterior border of the pygidium, an arrangement that must have ensured a close fit of the two shields in enrollment. Pygidium widest at anterior end, semielliptical, with strong relief. Axis elevated, well defined by the axial furrow, tapered, occupying about three-fourths of the pygidial length, unfurrowed. Articulating half-ring short (sag.), defined by a deep articulating furrow. Pleural regions convex and downsloping. Anterior border with sharp geniculation at one-third the distance from the axial furrow to the lateral margin; articulating facet well developed. Border narrow and but slightly elevated laterally, defined by a very shallow border furrow, but elevated at the level

of the posterior end of the axis. Beyond this elevation the border appears concave upward in posterior view, while the border furrow widens and the border becomes almost flat medially. Doublure wide, sloping but slightly inward and forming an almost vertical face. The edge of the doublure does not partake of the downward curve of the posterior border, hence the doublure is much narrower in its posteriormost portion. Doublure with irregular terrace lines and smooth margin. Upper surface of cephalon and pygidium perfectly smooth. Length of largest pygidium 11 mm.

Occurrence.—Collections cs-4 and USGS 4216, North Chatham.

Types.—Holotype: U.S.N.M. 145995. Paratypes: U.S.N.M. 145996-7.

BOLBOPARIA Rasetti, new genus

Description.—Cephalon with strong relief. Glabella well tapered, pointed in front, highest posteriorly where it extends into an upright spine. Lateral furrows short, of generalized pattern. Occipital furrow distinct, occipital ring short (sag.) and simple. Cheeks as a whole forming a subquadrate area in dorsal view, rising from a low posterior part to their highest point near the anterolateral angles, here bulging and overhanging the lateral border. The relatively long (sag.) preglabellar field is a broad depression separating the bulging cheeks. Anterior portion of border expanded; border narrowest laterally under the bulge of the cheeks, widening again toward the genal angle, extended into a pair of small, lateral spines and near the genal angle carrying one or more pairs of tubercles. In front of the genal angle the lateral border furrow merges with the posterior border furrow, at considerable distance from cephalic margin. Posterior border furrow directed obliquely outward and forward from the axial furrow, sharply turning outward after merging with the lateral border furrow, and reaching the lateral cephalic margin well in advance of the genal angle which bears a small spine.

Pygidium semielliptical, strongly convex transversely. Axis well defined, long, with numerous rings, the second bearing a large spine. Pleural regions unfurrowed; border narrow, extended into minute, downward-directed spines. Surface of test densely granulate in the three known species.

Type species.—*Bolboparia superba* Rasetti, new species.

Occurrence.—Later Lower Cambrian of New York and Quebec.

Discussion.—This is probably the most distinctive of all the new genera of Eodiscidae described herein. The short, downsloping

glabella and the bulging cheeks give it a very peculiar aspect. Among previously known forms it might perhaps be compared with *Calodiscus walcotti* Rasetti (1952), unfortunately known from a single, somewhat incomplete cephalon. This form also has a pointed, but much longer, glabella, whose posterior portion is extended into a spine. The cheeks, however, have a normal shape.

BOLBOPARIA SUPERBA Rasetti, new species

Plate 3, figure 1; plate 5, figures 1-6

Available material.—A few cephalo, small and more or less fragmentary excepting the holotype which is a large, almost perfect example. Also a thoracic segment attributed to the species.

Description.—Cephalon somewhat wider than long, widest at the posterior third, slightly narrowed toward the genal angle, pointed in front. Glabella occupying about two-thirds of the cephalic length, defined by a very deep axial furrow, well tapered, pointed in front, extended into a slender almost vertical spine just in front of the occipital furrow. Lateral furrows short, merging with the axial furrow; two pairs relatively deep, one additional pair barely visible. Occipital furrow straight, deeper at the sides, but not quite connecting with the axial furrows; occipital ring wider medially, with rounded outline. Cheeks bounded by an irregular line, consisting of strongly oblique posterior border furrow, followed by an almost longitudinal section of the lateral border furrow; at this point the cheeks are widest, then narrow again for a considerable, fairly straight portion; then the outline curves sharply inward in correspondence with the highest part of the bulge and becomes fairly straight, transverse in the anterior portion. The border furrow is well marked all around the cheeks and attains its maximum depth anterolaterally. The border extends into a pair of small, slender spines located somewhat back of the level of the anterior end of the glabella. Two rounded tubercles are located in the wider portion of the lateral border just in front of the posterior border; as mentioned in the generic diagnosis, a deep furrow separates here the lateral border, elevated into the posterior tubercle, and the posterior border, carrying the short genal spine.

Entire surface very densely covered with granules of various sizes; the largest appear broken at the tip and may represent the bases of short spines. Length of largest (holotype) cephalon 9.0 mm, width 11.0 mm.

A peculiar thoracic segment is attributed to the species because

the ornamentation of the pleura is similar to that of the cephalon. On each side of the axis there is an oblique furrow, directed outward and forward, reaching the axial furrow at the anterior corner of the ring. The pleura is flat and horizontal for most of its length, with a furrow paralleling and close to the posterior margin. The anterior margin has a very sharp geniculation, where it bends backward and downward, forming a marked facet. At the fulcrum a very narrow ridge is set off near the anterior margin by a shallow furrow, a feature also observed in *Serrodiscus subclavatus*. The distal end forms a short, sharp spine directed outward and backward.

Occurrence.—Collection cs-4, North Chatham.

Types.—Holotype: U.S.N.M. 145998. Paratypes: U.S.N.M. 145999.

BOLBOPARIA ELONGATA Rasetti, new species

Plate 3, figure 2; plate 5, figures 7-12

Available material.—A few cephalata, of which two reasonably complete, and three tentatively assigned, incomplete pygidia.

Description.—The cephalon is so similar to the type species that it is sufficient to point out the differences. Cephalon somewhat longer than wide. Glabella proportionately narrower and longer than in *B. superba*, bearing the same kind of lateral furrow and posterior spine. Anterior cephalic outline somewhat more sharply pointed; cheeks bulging anteriorly but not as much as in the type species; outline at the anterolateral corners turning even more abruptly than in that species. Posterior portion of border furrow even more oblique than in *B. superba*, forming an angle of 45° with the axis of the body. Widened posterior portion of lateral border bearing two pairs of tubercles as in preceding species. Genal angle not well preserved. Length of largest cephalon 8 mm. Ornamentation as in preceding species.

Three incomplete examples of a pygidium undoubtedly belong to *Bolboparia* as they match the unique ornamentation of the cephalata. However, the reference to *B. elongata* rather than *B. superba*, suggested by the relatively narrow shape, is tentative. Axis moderately wide, slightly tapered, defined by deep axial furrows, almost reaching the posterior border, furrowed for entire length, showing approximately 12 rings; end portion not well preserved. A broad-based spine on the second ring encroaches on the adjacent ring furrows. Pleural regions attaining a vertical slope, almost concealing the border in dorsal view. Border furrow well impressed; border vertical,

extended into about 12 pairs of minute spines. Length of largest pygidium 8 mm.

Occurrence.—Collection cs-4, North Chatham.

Types.—Holotype: U.S.N.M. 146001. Paratypes: U.S.N.M. 146002.

BOLBOPARIA CANADENSIS Rasetti, new species

Plate 5, figures 13, 14

Available material.—A single, well-preserved cephalon.

Description.—Cephalon relatively broad and short as in *B. superba*. Glabella somewhat longer in proportion to the cranidium, long and narrow, subconical, pointed in front. Three pairs of lateral furrows impressed, the posteriormost pair deep, short, pit-like, the other two similar but increasingly shallow. The glabellar spine is broken off, but its base shows that it was large and equally located as in *B. superba*. Occipital furrow straight, of even width throughout; occipital ring short and simple. Outline of the cheeks of the same general type as in *B. superba*, but differing in several details. The posterior portion, from the axial furrow to the widest point of the cheeks, is almost straight, since there is hardly any change of direction between the posterior border furrow and the posterior portion of the lateral furrow. Where these furrows meet, there is the usual deep furrow directed toward the cephalic margin; but in the present species this furrow extends also inward and forward, forming a broad, shallow depression across the cheek reaching the axial furrow at the level of the middle pair of glabellar furrows. At the widest point, the cheek outline forms a narrowly rounded angle, continues straight forward and somewhat inward to the anterolateral corners where the cheek attains its highest elevation, and then curves to a transverse inward course as in *B. superba*. As a whole the cheeks acquire thereby a peculiar subhexagonal outline. The border furrow and border are much like the other species, except that there is only one, large tubercle at the posterior end of the lateral border. The small lateral border spines are in the same position as in *B. superba*. Ornamentation identical with the other two species of the genus. Length of cephalon 4.5 mm, width 4.8 mm.

Occurrence.—The single known specimen was collected by Mr. Claude Hubert when mapping an area near the south shore of the St. Lawrence River in Quebec. The collection, designated as 63-F24, is stated to be made from a calcarenite bed a half mile north of Elgin Station, L'Islet County. The locality is about 60 miles northeast of

Levis. Unfortunately no other identifiable fossils were recovered from this bed, although trilobite fragments presumably representing *Olenellids* were observed. Lower Cambrian strata are known from this general area, and were designated by the writer (Rasetti, 1964) the Charny formation, to avoid the confusion associated with names previously in use. The easternmost occurrence of identified Lower Cambrian beds in place (the *Botsfordia pretiosa* shale) previously reported was about 20 miles northeast of Levis; hence Mr. Hubert's finding extends the known presence of Lower Cambrian strata 40 miles northeast. Lower Cambrian fossils at many other localities farther east are only found in boulders in Lower Ordovician conglomerates.

It should be pointed out that the only Lower Cambrian Eodiscid trilobites previously known from the Charny formation (Rasetti, 1945) belong to the family Pagetiidae. The same applies to the forms described (Rasetti, 1948) from conglomerate boulders. However, Raymond (1913) mentioned the presence of a blind Eodiscid, *Serrodiscus speciosus*, in the boulders at Bic. The writer, who collected thousands of Lower Cambrian trilobite specimens from that and nearby localities, was unable to find this species or any other blind Eodiscid. Search in the collections of the Geological Survey of Canada and the U.S. National Museum failed to yield any such material from the Bic locality. Hence the writer (1948) did not include *Serrodiscus speciosus* in the list of species from the Lower Cambrian of the Quebec conglomerates.

Recently two good specimens of *Serrodiscus speciosus*, one cephalon and one pygidium, bearing labels of the Bic locality and preserved in the characteristic, light-gray limestone prevailing in those conglomerates, were discovered in the collections of the New York State Museum. The writer was able to examine these through the courtesy of Dr. Donald W. Fisher. It is thus now ascertained that there are at least two blind Eodiscids in the Lower Cambrian of Quebec.

Type.—Holotype: Geological Survey of Canada No. 19887.

Genus *CALODISCUS* Howell, 1935

Type species.—*Agnostus lobatus* Hall.

CALODISCUS FISSIFRONS Rasetti, new species

Plate 9, figures 17-21

Available material.—A few cephalata, mostly fragmentary, and two tentatively assigned pygidia.

Description.—Glabella divided by a broad transverse furrow into anterior and posterior lobe; lobation more marked in larger individuals. Anterior lobe rounded, slightly narrower than posterior lobe; the latter rising steeply and extended upward and backward beyond the occipital ring; whether this extension is rounded or pointed at the extremity could not be determined, as this portion is incompletely preserved. One pair of short lateral furrows is visible on the posterior lobe. Occipital ring short (sag.), mostly masked in dorsal view by the glabellar extension, directed inward and backward at the sides. Cheeks strongly convex, in their posterolateral part overhanging the border furrow. Border expanded medially and causing a slight median inbend of the border furrow which here forms a depression by merging with the axial furrow; border narrowing gradually toward the genal angle. Posterior cephalic border poorly preserved. Surface of test faintly reticulate; lateral border with four or five pairs of low tubercles.

Pygidium tentatively referred to the species on account of similar ornamentation with axis well defined by deep axial furrows, showing about seven rings plus a terminal unsegmented section, almost reaching border. The first three rings may have had a node. Anterior border furrow deep and wide, with well-developed geniculation and facet. Lateral and posterior border furrow and border narrow throughout. Pleural regions unsegmented, very convex like the cheeks.

Width of largest cephalon 9.5 mm; length of holotype cephalon 4.6 mm, width 5.6 mm. Length of largest pygidium 5.0 mm, width 6.0 mm.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—This species differs considerably from *C. lobatus* in the shape of the glabella, divided by a broad transverse furrow and with the rear lobe extended backward above the occipital ring. However, the presence of one or more, shallow transglabellar furrows is a feature present in species obviously congeneric with *C. lobatus*, and even in the form *agnostoides* of this species which Lochman (1956) showed to intergrade with the typical form. *Calodiscus helena* (Walcott) has a broad, very shallow transglabellar furrow and a rearward extension of the glabella, although not as pronounced as in the present species, and on the whole the cephalon of *C. helena* and *C. fissifrons* are very similar. The pygidium of *C. helena*, however, differs considerably in the broad, paucisegmented axis from any pygidium observed at the North Chatham locality.

Types.—Holotype: U.S.N.M. 146004. Paratypes: U.S.N.M. 146005.

CALODISCUS RETICULATUS Rasetti, new species

Plate 1, fig. 1; plate 7, figures 12-18

Available material.—A few cephalon, mostly fragmentary.

Description.—Glabella divided by a deep, wide transverse furrow into two lobes. Anterior lobe subovate, very convex, anteriorly sloping down almost vertically to the broad depression formed by the coalescence of the axial and border furrows. Glabella constricted at the transverse furrow. Posterior lobe widening backward from the transverse furrow, rising steeply, extended well beyond the general outline of the cephalon; seemingly rounded at the posterior end, although this portion is not completely preserved in any of the specimens. Occipital ring differentiated under the rearward glabellar extension, at least at the sides where it is directed rather backward than inward. Cheeks very convex, at least posteriorly where they overhang the lateral border furrow. Border expanded medially as in preceding species, slightly convex, narrowing toward the genal angle, lacking tubercles. Posterior border set off by a wide, deep furrow, rather wide in distal portion; genal angle narrowly rounded, lacking spine.

Surface of test covered with raised lines forming a reticulate pattern. The largest cephalon has a width of 10.5 mm and a length of approximately 10 mm.

Occurrence.—Collections cs-4 and U.S.G.S. 4216, North Chatham.

Discussion.—This species is closely related to the preceding, differing in the deeper division of the glabella by a transverse furrow, greater elevation of the two glabellar lobes, reticulate ornamentation, and lack of tubercles on the border. Clearly the present species is so strikingly different from *Calodiscus lobatus* that, were intermediate forms unknown, reference to the genus would hardly be suggested. However, when one considers the series *Calodiscus lobatus*, *C. lobatus agnostoides*, *C. helena*, *C. fissifrons*, and *C. reticulatus*, it appears difficult to decide where to place a possible generic boundary.

Types.—Holotype: U.S.N.M. 146006. Paratypes: U.S.N.M. 146007 and 146008.

CALODISCUS OCCIPITALIS Rasetti, new species

Plate 9, figures 22, 23

Available material.—One cephalon.

Description.—Cephalon semielliptical, of low convexity. Glabella elevated above the cheeks, higher posteriorly, with little longitudinal convexity, parallel-sided in the posterior two-thirds, anteriorly taper-

ing to a fairly sharp point, occupying about two-thirds of the cephalic length, unfurrowed. Occipital furrow deeper laterally, impressed throughout; occipital ring extended into a robust, horizontal spine longer than all the rest of the cephalon. Cheeks lowest medially, slightly convex, their outline forming a sharp angle at the posterolateral corner. Border furrow well impressed; border convex, fairly wide, of about even width but for a slight narrowing toward the genal angle, bearing a few, indistinct tubercles. Posterior border furrow deep and wide; posterior border with geniculation about half-way between axial furrow and genal angle, the latter lacking a spine. Surface of test smooth. Length of cephalon (exclusive of occipital spine) 3.4 mm, width 3.8 mm.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—This form seems referable to *Calodiscus* even though it differs in several features from all previously described species. Its chief distinguishing characteristics are the relatively short glabella, well-impressed occipital furrow, excessively long occipital spine, narrowness of the border furrow, and even width of the border.

Types.—Holotype: U.S.N.M. 146003.

LEPTOCHILODISCUS Rasetti, new genus

Description.—Cephalon of moderate convexity. Glabella defined by deep axial furrow but not rising much above the cheeks, narrow and long, tapered, pointed in front, not reaching the anterior border, unfurrowed. Occipital furrow deep; occipital ring extended into spine. Cheeks everywhere convex, not separated in front by a preglabellar depression. Border very narrow, wire-like, well defined by narrow border furrow, narrowest in frontal portion, somewhat widened laterally. Posterior border furrow deep; posterior border widening distally, with geniculation near genal angle. Surface of test in type species punctate.

Type species.—*Leptochilodiscus punctulatus* Rasetti, new species.

Occurrence.—Late Lower Cambrian of New York.

Discussion.—This simple eodiscid cephalon does not seem referable to described genera. Compared with *Calodiscus*, it shows important differences that are sufficient to doubt a close relationship. In *Calodiscus* the anterior border is much wider, usually widest medially, and the cheeks are separated in front of the glabella by a more or less extended preglabellar depression. The glabella of *Leptochilodiscus* is unusually long and pointed. The deep occipital furrow and spinose occipital ring also are not suggestive of *Calodiscus*.

LEPTOCHILODISCUS PUNCTULATIS Rasetti, new species

Plate 1, figure 5; plate 11, figures 1-7

Available material.—Four cephala in fair state of preservation.

Description.—Cephalon of about equal length and width, well rounded anteriorly. Glabella rising steeply above the occipital furrow, then sloping down toward a low anterior end without much longitudinal convexity, tapered at low, almost uniform rate but for a barely perceptible constriction at one-third the distance from the anterior end, reaching not far from the anterior border furrow. Occipital furrow deep and wide; occipital ring at lower level than glabella, extended into a slender, moderately long spine. Axial furrow deep except in its anteriormost portion. Cheeks rising above the axial furrow, convex transversely, in posterior portion sloping down steeply to border furrow. Border defined by narrow but fairly deep border furrow, convex, wire-like, very narrow in frontal portion. A unique, though inconspicuous, feature of the border is a slight widening that occurs at the point where the margin forms an angle of 45° with the sagittal line; here a small pit, distinguishable in all specimens, occurs on the upper surface. The portion of the border posterior to the pit remains wider than the frontal border. Another characteristic feature of the border is its sinuous outline in frontal view; the border curves slightly downward medially, upward at the sides of the median downbend, then again downward to assume a smooth course laterally. The slight crushing of the test in some specimens has made these features visible in dorsal view also. Posterior cephalic border with straight margin from axial furrow almost to genal angle, at this point reaching maximum elevation and sharply turned downward and forward to join the lateral border, possibly extended into a genal spine. Posterior border furrow deep and wide. Surface of cheeks definitely pitted in all specimens; similar but shallower ornamentation on glabella. Length and width of largest cephalon 4.4 mm.

Occurrence.—Collections cs-4 and U.S.G.S. 4216, North Chatham.

Types.—Holotype: U.S.N.M. 146009. Paratypes: U.S.N.M. 146010 and 146011.

LITOMETOPUS Rasetti, new genus

Description.—Cephalon relatively wide, almost semicircular, with considerable relief. Glabella long and narrow, slightly tapered, reaching the anterior border furrow which therefore merges medially

with the axial furrow. Glabellar and occipital furrows entirely obsolete. Cheeks convex; border wide, convex, downrolled into the doublure. Posterior cephalic border with a blunt tooth, extended at the genal angle into strong spine.

Pygidium similar in shape to cephalon, more tapered posteriorly. Axis reaching posterior border, unfurrowed, well defined by axial furrow. Border furrow well impressed; border flat, fairly wide; doublure sloping inward at about 45° to vertical, with serrated margin. Size large for an Eodiscid.

Type species.—*Litometopus longispinus* Rasetti, new species.

Occurrence.—Late Lower Cambrian of New York.

Discussion.—This form is a close relative of *Serrodiscus*, sharing with that genus the shape of the glabella, the general structure of the pygidium, and a slightly serrated doublure. Chief differences are the width and convexity of the cephalic border, the entire lack of preglabellar field, the unusual tooth at the posterior cephalic border, and the strong genal spine. The last two features also distinguish the genus from *Cobboldites comleyensis*, which has an equally long glabella and a similar pygidium. The very large size of *Litometopus* contrasts with the small size of the known examples of *Cobboldites*.

LITOMETOPUS LONGISPINUS Rasetti, new species

Plate 3, figure 3; plate 8, figures 1-9

Available material.—A few cephalata and a larger number of pygidia.

Description.—Cephalon 1.3 times wider than long, with uniformly rounded anterior and lateral outline. Glabella widest at the undifferentiated occipital ring, with slightly concave lateral outline, rounded in front, well defined by the axial furrow, convex in both directions. Cheeks very convex, sloping down steeply to the deep border furrow. Border wide anteriorly, narrowing toward the genal angle, convex, downrolled into doublure, showing a pair of small lateral spines somewhat anterior to the cephalic midlength. Border furrow becoming very shallow at the genal angle; genal spine strong, curving inward, not greatly tapered, when complete probably equaling the cephalon in length. Posterior border furrow well impressed; posterior border straight from axial furrow to near base of genal spine, where it forms an obtuse tooth set off by a narrow, short furrow. Surface of test sparsely punctate, more distinctly in larger individuals. The largest (holotype) complete cephalon has a length of 8.3 mm and a width of 10.7 mm. However, a large cephalon in the collection, crushed by the slumping of the sediment in such

manner that the anterior portion was bent under the posterior part, but nevertheless recognizable, has a width of 30 mm excluding the genal spines.

Pygidium 1.4 times wider than long. Axis well defined by the axial furrow, just touching the border furrow, not showing segmentation except for the articulating half-ring. Pleural regions convex. Anterior border with sharp geniculation at two-fifths the distance from axial furrow to lateral angle; facet well developed. Lateral border flat, defined by sharp change in slope, widening from anterior angle to midlength, then narrowing again, narrowest medially. Doublure somewhat wider than border, marked with terrace lines that follow the blunt serrations of the margin. Surface pitted like the cephalon. Length of largest pygidium 16 mm, width 22 mm.

From the proportions of the various parts and the size of the largest cephalon, the presence of individuals about 50 mm long may be inferred. This may be the largest size for an Eodiscid ever reported.

Occurrence.—Collection cs-4, North Chatham.

Types.—Holotype: U.S.N.M. 146012. Paratypes: U.S.N.M. 146013.

OODISCUS Rasetti, new genus

Description.—Cephalon tending to a subquadrate shape. Glabella with undifferentiated occipital ring ovate, occupying more than one-third of the cephalic width, strongly elevated, totally unfurrowed. Preglabellar field short (sag.). Cheeks convex and downsloping. Border furrow and border well defined all around the cephalon; lateral border may show one or two pairs of short spines; in one species the frontal border bears a pair of tubercles. Posterior border with sharp geniculation and short spine at one-third the distance from axial furrow to rounded genal angle.

Pygidium with tapered, unfurrowed axis not reaching posterior border. Border furrow and border as in cephalon; border lacking marginal spines.

Type species.—*Oodiscus subgranulatus* Rasetti, new species.

Occurrence.—Late Lower Cambrian of New York.

Discussion.—The type species and others included in the genus have a rather simple structure which, nevertheless, distinguishes them clearly from previously known Eodiscidae such as *Serrodiscus* and *Calodiscus*. The glabella is wider relative to the entire cephalon than in these genera, and has an oval shape; the undifferentiated occipital ring extends farther back than usual relative to the cheeks. The

geniculation of the posterior cephalic border, marked by a short spine, is much closer to the axial furrow than in previously known Eodiscidae. The pygidium, compared with *Serrodiscus*, has a shorter axis and lacks marginal spines.

OODISCUS SUBGRANULATUS Rasetti, new species

Plate 1, figure 4; plate 10, figures 1-10

Available material.—Several cephalons and pygidia more or less completely preserved.

Description.—Cephalon somewhat widening forward from the genal angle, widest slightly in front of the midlength, well rounded anterolaterally, with almost straight portion of frontal outline. Glabella ovate, somewhat pointed in front, not reaching anterior border furrow, strongly elevated above the cheeks, sloping down from posterior to anterior end. Occipital furrow barely indicated by a pair of exceedingly shallow lateral depressions, very short (sag.), rounded. Cheeks strongly downsloping posteriorly, gradually flatter toward the anterior part; no preglabellar depression. Border somewhat convex, well defined by border furrow, of even width around the anterior half of the cephalon, narrowing toward the genal angle, bearing two pairs of small, short marginal spines, one pair at the level of the cephalic midlength, a second pair halfway between the first and the genal angle. Lateral border furrow continued into posterior border furrow; the latter directed outward and forward from axial furrow, curving outward distally, hence as a whole convex forward. Posterior border horizontal in inner third, then sharply downturned to reach the much lower level of the genal angle; a small, upright spine at the geniculation, usually broken in extracting the specimen from the matrix. Genal angle narrowly rounded.

Pygidium assigned to the species on the basis of similar shape and identical ornamentation, less convex than cephalon, about parallel-sided in anterior half, well rounded posteriorly. Axis widest at the base, not greatly elevated, tapered, unfurrowed, occupying two-thirds of pygidial length. Anterior border straight, transverse from axial furrow to geniculation which is relatively close to axial furrow, distally slanted backward and with marked facet, paralleled by well-impressed anterior border furrow; remainder of border furrow and border as in cephalon; border lacking spines. Doublure reflexed in usual manner.

Cheeks and pleural regions of the pygidium covered with small, sparse granules, of density variable in different individuals. The py-

gidia usually show one or two small median nodes on the anterior portion of the axis when the preservation is perfect. Length of largest cephalon 8.0 mm, width 8.8 mm. Length of largest pygidium 8.0 mm, width 8.0 mm.

Occurrence.—Collection cs-4, North Chatham.

Types.—Holotype: U.S.N.M. 146014. Paratypes: U.S.N.M. 146015.

OODISCUS BINODOSUS Rasetti, new species

Plate 10, figures 16-18

Available material.—Three cephalata, of which only the holotype well preserved. Pygidia may be present, but cannot be identified among similar species of the genus.

Description.—The cephalon is so similar to the type species that only the differences are listed. Glabella narrower and of more uniform elevation throughout its length, slightly longer, almost reaching the anterior border furrow. Border furrow and border somewhat wider; anterior border bearing a pair of low, closely spaced tubercles that somewhat encroach upon the border furrow. Lateral border spines seemingly absent. Posterior border furrow straighter than in type species; geniculation with small, upright spine. Surface of test smooth. Length of largest cephalon 6.5 mm.

Occurrence.—Collection cs-4, North Chatham.

Types.—Holotype: U.S.N.M. 146016. Paratypes: U.S.N.M. 146017.

OODISCUS LONGIFRONS Rasetti, new species

Plate 10, figures 20, 21

Available material.—A few cephalata, none of which well preserved.

Description.—Glabella of the same shape as in the type species, but longer, just reaching the anterior border furrow. Border furrow and border somewhat wider than in *O. subgranulatus*; anterior border furrow showing a slight median inbend where it merges with the axial furrow; anterior border lacking nodes. Lateral border seemingly lacking spines, but none of the specimens are well preserved enough for this feature to be established with certainty. Geniculation of posterior border as in the two preceding species. In the holotype a pair of low, inconspicuous nodes is present on the downsloping portion of the posterior border between the geniculation and the genal angle, but this feature is indistinct in the paratypes.

Occurrence.—Collection cs-4, North Chatham.

Types.—Holotype: U.S.N.M. 146018. Paratypes: U.S.N.M. 146019.

OODISCUS, species undetermined No. 1

Plate 11, figures 8-11

Available material.—A few pygidia, of which two well preserved.

Description.—Axis very prominent, unfurrowed, slightly tapered, rounded posteriorly, not reaching the posterior border furrow. Pleural regions convex and downsloping. Anterior border with geniculation relatively close to axial furrow and well-developed facet. Border furrow wide, relatively shallow. Border flat, rather wide. Anterior angles of pygidium sharp. Doublure sharply reflexed, apparently with smooth margin. Length of largest specimen 8.2 mm, width 8.0 mm. Surface of test smooth.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—This pygidium seems definitely to belong to *Oodiscus*, but it cannot be determined to which, if any, of the species based on the cephalata it should be referred. Compared with the pygidium assigned to *O. subgranulatus*, it has a more prominent and longer axis.

Disposition of material.—Figured specimens: U.S.N.M. 146020.

OODISCUS, species undetermined No. 2

Plate 11, figures 12, 13

Available material.—A few pygidia.

Description.—The pygidia in question do not appreciably differ in shape from those referred to *O. subgranulatus*, but lack the ornamentation of the cephalata and pygidia of that species. Hence they may belong to a similar species, possibly *O. binodosus*, that has a smooth cephalon. The assignment cannot be decided on the basis of the available evidence.

Occurrence.—Collection cs-4, North Chatham.

Disposition of material.—Figured specimens: U.S.N.M. 146021.

Genus SERRODISCUS R. and E. Richter, 1941

Type species.—*Eodiscus (Serrodiscus) serratus* R. and E. Richter.

SERRODISCUS SUBCLAVATUS Rasetti, new species

Plate 2, figure 1; plate 8, figures 10-19

Available material.—Numerous cephalata and pygidia, including one cephalon with two thoracic segments attached.

Description.—Glabella with totally undifferentiated occipital ring defined by an exceptionally deep axial furrow, strongly convex transversely, unfurrowed, slightly narrowed from the occipital ring to the level of the posterior third, then slightly expanded forward, sharply narrowed and somewhat pointed in front, reaching the border furrow. Cheeks very convex, posteriorly overhanging the border furrow, anteriorly separated by a narrow (tr.) prelabellar depression formed by the merging of the axial and border furrows. Border strongly convex, fairly wide, defined by a deep border furrow, contributing to the great relief of the cephalon. Tubercles on the border moderately elevated, generally seven or eight pairs present, about equally spaced. Posterior border furrow deep; posterior border straight from axial furrow to sharp geniculation which is located not far from genal angle and is marked by a short spine. A characteristic feature of the border is a very narrow, shallow furrow parallel and close to the posterior margin that sets off a slight, obtuse expansion. The articulated specimen shows that this feature corresponds to a similar one at the fulcrum of the anterior margin of the first thoracic segment. However, the geniculation of the posterior cephalic border with its spine is situated farther outward. In front of the spine the cephalic border curves downward and forward to join the lateral border which as usual is at a lower level; no sharp angle is formed, and the cephalic border is narrowest at this point.

First thoracic segment with anterior margin distally from the above-mentioned fulcrum sharply bent backward to form a well-developed facet. Axis not preserved. Second segment showing a very convex axial lobe and deep axial furrow. Pleural articulation between first and second segment with features similar to those present between the cephalon and the first segment, but more distally located. Anterior margin beyond the geniculation bent downward but not backward. Posterior margin with geniculation situated still farther outward, distally strongly bent forward and downward. Third thoracic segment not preserved.

Pygidium with strong relief. Axis prominent, defined by deep axial furrow, convex in both directions, totally unfurrowed, not quite reaching the border furrow. Articulating half-ring expanded medially by a rearward median inbend of the articulating furrow. Axis bearing a strong median spine at about four-fifths of its length; this spine is broken off in all pygidia except one specimen where it could be partly restored. Pleural regions strongly convex, near posterior end forming a narrow, convex band between the end of the axis and the border furrow. Border furrow deep; border narrower than in cepha-

lon, extended downward into a series of short spines somewhat visible in dorsal view by producing a wavy outline; seven or eight pairs of such spines are usually present. A. R. Palmer (private communication) suggested to the writer that such spines may fit the reverse side of the tubercles of the cephalic border when the animal is enrolled. The structures in the present species may support this interpretation since the tubercles and spines are in about equal numbers and similarly spaced.

Surface of cephalon and pygidium densely covered with fine granules. Length of largest cephalon 11 mm, width 11 mm. The entire pygidia recovered are somewhat smaller.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—Even though the close affinity to typical species of *Serrodiscus* can hardly be doubted, this form presents numerous differences from all those previously described. The most conspicuous features are the great convexity of the cephalon, depth of the axial furrows, unusual length and somewhat clavate shape of the glabella, and unfurrowed pygidial axis bearing a spine. The most similar form is an undescribed species from the Purley Shales of England (Rushton, private communication).

Types.—Holotype: U.S.N.M. 146022. Paratypes: U.S.N.M. 146023.

SERRODISCUS SPINULOSUS Rasetti, new species

Plate 7, figures 7-11

Available material.—A few cephalons and one pygidium.

Description.—Glabella with undifferentiated occipital ring widest at posterior end, narrowed forward for a short distance, then parallel-sided, strongly tapered in frontal portion and rather pointed medially, unfurrowed. Glabella of moderate convexity, anteriorly reaching the border on account of a sharp median inbend of the border furrow which thus merges for a short distance with the axial furrow. Occipital ring bearing a short spine. Cheeks slightly convex, downsloping. Border widest medially on account of the above-mentioned feature of the border furrow, narrowing toward the genal angle, bearing several pairs of very low, somewhat indistinct tubercles. Posterior border wide (exsag.), extended into short, sharply pointed genal spine. No geniculation features on posterior cephalic margin between axial furrow and genal spine. Cephalic border narrowest at posterolateral angles in front of genal spine.

Pygidium referred to the species with long, totally unfurrowed axis almost reaching posterior border. Articulating half-ring expanded

medially as in preceding species. Pleural lobes of moderate convexity; border furrow well impressed. Border fairly wide, convex, extended ventrally into a series of short spines, producing in dorsal view a waviness of the margin. Seemingly there was a spine on the posterior part of the axis.

Surface of test of cephalon and pygidium perfectly smooth. Length of largest cephalon 5.6 mm, width 5.2 mm. Length of pygidium 4.7 mm, width 5.6 mm.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—This form is fully typical of *Serrodiscus* in all respects excepting one unusual feature, the inbend of the anterior border furrow causing it to merge with the axial furrow. Other distinguishing features are the occipital and genal spines, the shape of the glabella, and the unfurrowed pygidial axis.

Types.—Holotype: U.S.N.M. 146026. Paratypes: U.S.N.M. 146027.

SERRODISCUS LATUS Rasetti, new species

Plate 10, figures 12-15

Available material.—Three cephalata, of which one excellently preserved.

Description.—Glabella with totally undifferentiated occipital ring slightly tapered, straight-sided, well defined by deep axial furrows, somewhat pointed in front, almost reaching the border, unfurrowed. Cheeks convex, rising somewhat above the axial furrows, steeply sloping to border furrow at the sides. Border furrow deep all around the cheeks, medially almost meeting the axial furrow. Border somewhat convex and on the average horizontal, widest medially and but slightly tapering to the genal angle, bearing a few pairs of low tubercles. Posterior border furrow and border about as wide as lateral border; posterior cephalic margin straight and transverse from axial furrow to geniculation, then turning downward and forward to the genal angle which bears a minute spine. Surface of test smooth. Length of largest cephalon 5.0 mm, width 6.2 mm.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—The cephalic features agree with *Serrodiscus*, but in the absence of a pygidium it is questionable whether the species should not rather be referred to *Calodiscus*, or possibly *Cobboldites*. The cephalon differs markedly from *C. speciosus* and other described species in the general outline, regularly curved in front rather than pointed, deep axial furrows, and great convexity of the cheeks.

Types.—Holotype: U.S.N.M. 146024. Paratypes: U.S.N.M. 146025.

SERRODISCUS, species undetermined

Plate 10, figure 19

Available material.—One incomplete cephalon.

Description.—Glabella approximately parallel-sided, rounded in front, not greatly elevated, occupying with the occipital ring two-thirds of the cephalic length. One pair of glabellar furrows, very broad and shallow, is impressed all across the glabella. Occipital furrow visible as a pair of shallow, broad depressions at the sides. Occipital ring somewhat elevated medially, rounded, lacking node or spine. Cheeks moderately convex, preserved only in their anterior part. Preglabellar field flat, fairly extended. Border furrow shallow; border wide, flat, apparently lacking tubercles. Anterior outline of cephalon unusually pointed medially. Surface of test smooth. Length of cephalon 5.6 mm.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—This cephalon cannot be referred to any described species, but is too incomplete to warrant a name. The proportions of the various parts are somewhat like *S. speciosus*, but the glabella is shorter and less tapered, the entire cephalon more nearly triangular, the border wider, and the occipital ring is raised at the posterior margin.

Disposition of material.—Figured specimen: U.S.N.M. 146028.

STIGMADISCUS Rasetti, new genus

Description.—Cephalon semielliptical, lacking lateral spines. Glabella approximately parallel-sided, rather pointed in front, rising above the downsloping cheeks, elevated in front of the occipital furrow. Glabellar furrows impressed as two pairs of deep lateral pits close to the axial furrow. Occipital furrow similarly deepened into a pair of pits. Occipital ring well differentiated, bearing a node or spine. Cephalic border narrow, defined by shallow border furrow. Posterior border bearing a pair of short spines, located either about halfway between the axial furrow and the genal angle, or close to the genal angle. Surface of test smooth. Other parts of exoskeleton unknown.

Type species.—*Stigmatiscus stenometopus* Rasetti, new species.

Occurrence.—Late Lower Cambrian of New York.

Discussion.—The genus is proposed for two species whose most distinctive character is the pit-like structure of the glabellar furrows, a feature so far never observed in the Eodiscidae. The type species shows marked affinity with *Acidiscus*, where the glabellar furrows are relatively short and deep and the occipital furrow has a similar structure. The other described species, *Stigmadiscus gibbosus*, shows some resemblance to an Agnostid cephalon in the proportions of the various parts. Whether this similarity is purely accidental, or we are dealing with an Eodiscid evolving into an Agnostid, cannot be decided at present, especially in the absence of thorax and pygidium.

STIGMADISCUS STENOMETOPUS Rasetti, new species

Plate 3, figure 5; plate 12, figures 1-7

Available material.—Several cephala, of which two fairly complete.

Description.—Cephalon of low convexity. Glabella relatively narrow, slightly tapered from the occipital ring to the anterior pair of lateral furrows, very slightly expanded in front, somewhat pointed, occupying about two-thirds of cephalic length. Axial furrow deep posteriorly, shallower anteriorly. Longitudinal profile of glabella rising gradually from front to back, where it reaches its highest elevation in the form of a rounded ridge that drops abruptly to the level of the occipital furrow. In some of the specimens there is an indication of a small, broken spine at this highest point, whereas other individuals where the test at this place is well preserved do not show a spine. Occipital ring moderately long (sag.), bearing a short spine. Cheeks slightly convex, downsloping; lateral border narrow, of even width, defined by a border furrow that becomes progressively shallower and broader forward. Posterior border furrow deeper than lateral border furrow, almost straight, slightly convex forward, joining the lateral border furrow near the genal angle which is fairly sharp but seemingly not extended into a spine. Posterior cephalic border wider and better defined than lateral border, extended into a short, horizontal spine located somewhat closer to the axial furrow than to the genal angle. The portion of the posterior border beyond the spine is somewhat slanted forward. Surface of test smooth. Length of holotype cephalon 9.0 mm, width 9.9 mm. The largest glabella indicates a cephalon 12.5 mm in length.

Occurrence.—Collection cs-4, North Chatham.

Types.—Holotype: U.S.N.M. 146029. Paratypes: U.S.N.M. 146030.

STIGMADISCUS GIBBOSUS Rasetti, new species

Plate 3, figure 4; plate 12, figures 8-13

Available material.—About half a dozen cephalons, mostly in mediocre state of preservation.

Description.—Cephalon equally wide and long, moderately convex, semielliptical. Glabella narrowed forward in its posteriormost portion from the wider occipital ring, almost parallel-sided in its medial part, rapidly tapered and somewhat pointed in its anterior fourth. Two posteriormost pairs of lateral furrows deep, short, pit-like; no indication of other pairs. A broad transglabellar depression is located somewhat in advance of the anterior pair of lateral furrows. The glabella rises in bulbous shape behind this depression and drops sharply to the occipital furrow. The occipital furrow is impressed at the sides in form of a pair of small pits, shallower than the glabellar furrows, not connecting with the axial furrow, and is extended medially into a shallower, still well-impressed portion. Occipital ring short, bearing a small node. Cheeks rather flat in front of the glabella, not forming a definite depression. Border furrow shallow and poorly defined anteriorly, gradually becoming narrower and deeper toward the genal angle. Border poorly defined, somewhat convex, reduced in width toward the genal angle. Posterior border furrow directed outward and forward, forming a considerable angle with the posterior cephalic margin and hence producing an elongate, triangular posterior border which extends into a short spine located very close to the genal angle. The posterior cephalic margin slopes down somewhat in connecting the posterior with the lateral border. Surface of test smooth. Length and width of largest cephalon 6.8 mm.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—This form seems closely related to the type species, with which it shares the pit-like glabellar furrows and the elevation of the posterior portion of the glabella. In other respects there are conspicuous differences, which made the writer hesitate whether the two should be referred to the same genus. In *Stigmatiscus gibbosus* the glabella is larger in proportion to the whole cephalon, the occipital ring is shorter and lacks a spine, the glabellar boss is defined both in front and back, instead of rising gradually in the frontal part as in *S. stenometopus*. Perhaps the most significant difference of all is in the position of the spine on the posterior cephalic border, in the present species close to the genal angle so that it may be called a "genal" spine. These various differences give to *Stigmatiscus gib-*

bosus a somewhat Agnostid-like aspect that is completely lacking in the type species.

Types.—Holotype: U.S.N.M. 146031. Paratypes: U.S.N.M. 146032.

Undetermined pygidia

Several pygidia, undoubtedly belonging to the family Eodiscidae and possibly to some of the named species, are described hereafter. Possible assignments are suggested in some cases.

Undetermined pygidium No. 1

Plate 11, figures 17-21

Available material.—Three examples.

Description.—Pygidium of strong convexity especially in the transverse direction. Axis strongly prominent, moderately tapered, reaching the posterior border furrow, showing eight rings plus a terminal section defined by exceedingly shallow furrows; articulating half-ring short (sag.), articulating furrow straight. Pleural regions convex, laterally sloping down vertically to border furrow. Border very narrow, ventrally extended into 8 to 10 pairs of short, somewhat backward-directed spines. Outline of border arched in posterior view. Surface of test with very shallow puncta, not equally distinct in the available specimens. Length of largest pygidium 4.4 mm, width 4.4 mm.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—The narrowness of the border and the shallowly punctate surface suggest the possibility that this is the pygidium of *Leptochilodiscus punctulatus*.¹

Disposition of material.—Figured specimens: U.S.N.M. 146033.

Undetermined pygidium No. 2

Plate 11, figures 14-16

Available material.—Three more or less complete examples.

Description.—Pygidium with considerable relief. Axis prominent, relatively wide, tapered to a rather sharp point, almost reaching the posterior border furrow, composed of six rings plus a terminal sec-

¹ Copious material, collected from another locality after this paper was written, unquestionably supports this assignment.

tion. Ring furrows with peculiar structure, deepening to pair of pits at the sides some distance from the axial furrow; the medial portion of the ring furrow narrower and shallower, concave toward the front. The axial rings bore spines of decreasing length, broken off in the available specimens. Pleural regions unfurrowed, downsloping; border furrow narrow but deep; border narrow, but expanded into four pairs of wide, short, somewhat blunt spines about evenly spaced. The spines are directed outward, not downward as in many species of *Serrodiscus*. Surface of test smooth. Length of largest pygidium 5.7 mm.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—It is questionable whether this peculiar pygidium belongs to any of the cephala known from the locality.

Disposition of material.—Figured specimens: U.S.N.M. 146034.

Undetermined pygidium No. 3

Plate 10, figure 11

Available material.—A single, well-preserved example.

Description.—Pygidium of low convexity, almost semicircular. Axis defined anteriorly by very shallow axial furrows, the remainder undifferentiated from the pleural regions. Articulating half-ring and furrow well defined. Anterior outline straight in dorsal view, with geniculation about halfway between axial furrow and anterior angle, with border bent downward but not appreciably backward. Border furrow well impressed, border flat, of almost even width throughout. Doublure vertical, narrow, with smooth margin. Surface of test smooth. Length of pygidium 7.0 mm, width 10.3 mm.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—In the general shape this pygidium recalls *Litometopus longispinus*, but differs markedly in the lesser convexity and especially in the almost complete obsolescence of the axial furrows. It should presumably be associated with a cephalon with poorly differentiated glabella, but no such form is present in the collection.

Disposition of material.—Figured specimen: U.S.N.M. 146035.

Family OLENELLIDAE Vogdes, 1893

Olenellids are relatively common in the faunule, but owing to the thinness of their test, they are usually much more fragmentary than the Eodiscids. Cephala of three different species have been identified.

These are all represented by small, evidently immature specimens. No fragments of either cephalo or thoracic segments seem to indicate the presence of animals much larger than the cephalo illustrated.

Genus *PAEDEUMIAS* Walcott, 1910

Type species.—*Paedeumias transitans* Walcott.

PAEDEUMIAS, species undetermined No. 1

Plate 12, figures 23-25

Available material.—Fairly numerous, complete cephalo from 1.5 to 4 mm in length.

Description.—Glabella well-defined, narrow, parallel-sided, with frontal lobe not wider than the posterior lobes. Frontal lobe ovate, defined by a furrow deep at the sides, shallow but distinct medially. Next three lobes of about equal length, separated by deep, transverse furrows at the sides, not extended medially. Occipital furrow similar to the preceding glabellar furrows; occipital ring apparently extended into a short spine, not well preserved in any of the cephalo. Palpebral lobes separated by a shallow depression from frontal glabellar lobe, with curvature increasing backward, almost reaching the posterior cephalic margin. There is a fairly wide, well-defined space between the glabella and the palpebral lobe. Border wide, convex, of about the same width frontally and laterally. Distance from anterior end of glabella to anterior border furrow almost equal to length of frontal glabellar lobe. A median ridge connecting the front end of the glabella with the border furrow is visible at least in the larger specimens. From the posterior end of the palpebral lobe a narrow outward-directed ridge reaches the posterior cephalic margin at the base of a moderately long intergenal spine. Beyond this spine, the posterior margin turns slightly forward to the base of the genal spine, which is less conspicuous than the intergenal spine.

The preceding description was based on cephalo about 4 mm in length. In a fairly well-preserved cephalon 1.5 mm in length illustrated herein, the intergenal spines are very close to the genal angle; in addition, there is a pair of small procranial spines. These changes in the relative size and position of the spines, as far as can be ascertained from the meager material available, seem to parallel those observed by Palmer (1957) in the ontogeny of *Olenellus gilberti*.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—The reference to the genus is chiefly suggested by the considerable length of the preglabellar field and the presence of a preglabellar ridge; however, these may be juvenile features. The present form is almost identical with an immature cephalon attributed to *Paedeumias* from a conglomerate boulder near Levis, Quebec, figured by the writer (Rasetti, 1948, pl. 2, fig. 5). If this cephalon is conspecific with the larger one from the same locality (Rasetti, 1948, pl. 2, fig. 6), the reference to *Paedeumias* seems well founded. Comparison with immature cephalons of *Elliptocephala asaphoides* shows that the present species differs in several respects.

Disposition of material.—Figured specimens: U.S.N.M. 146036.

PAEDEUMIAS?, species undetermined No. 2

Plate 12, figures 19, 20

Available material.—A few, incomplete cephalons.

Description.—Glabella flat, hardly elevated above the cheeks, defined by a shallow axial furrow only in the portion corresponding to the posterior lobe; the two preceding lobes extend, undifferentiated from the cheek, as far as the palpebral lobe. Glabella tapered, with frontal lobe considerably narrower than the posterior lobe and the occipital ring. Three pairs of glabellar furrows increasing in depth rearward, fairly well impressed at the sides, fading out medially, oblique and approximately parallel to each other. Occipital furrow of identical character; occipital ring as long as the last glabellar lobe, bearing a node. Palpebral lobes broad, scarcely elevated, posteriorly reaching the level of the midlength of the occipital ring. A narrow rim, set off by a narrow furrow, encircles the palpebral lobe. All the cephalons are broken at the outer edge of this rim, i.e., at the upper boundary of the visual surface of the eye, where the facial suture is located in opisthoparian trilobites; the remainder of the pleural portions of the cephalon is completely missing. The area comprised between the glabella and the palpebral lobe is very narrow, and defined only posteriorly as previously indicated. Length of glabella plus occipital ring 5-6 mm.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—This form has features unusual among the Olenellids of the late Lower Cambrian, especially the tapered glabella and the well-defined narrow rim around the palpebral lobe. It cannot be identified with any described species known to the writer.

Disposition of material.—Figured specimens: U.S.N.M. 146037.

Genus *OLENELLUS* Billings, 1861

Type species.—*Olenus thompsoni* Hall.

OLENELLUS, species undetermined

Plate 12, figures 21, 22

Available material.—A few, incomplete cephal.

Description.—Glabella well defined by a deep axial furrow, on the average somewhat expanded forward. Frontal lobe large; second lobe short and wide, set off by narrow, fairly deep lateral furrows at the sides both from the frontal lobe and the third lobe; both pairs of furrows become very shallow medially. The second lobe expands laterally to touch the palpebral lobe, from which it is separated by an oblique furrow, extension of the first pair of glabellar furrows. Third and fourth glabellar lobes narrower, bounded by the axial furrow laterally, far from reaching the palpebral lobe; third pair of lateral furrows and occipital furrow similar to second pair of furrows. There was a node, broken off in the available specimens, across the occipital furrow, rather than on the occipital ring as usual. Palpebral lobes wide, long, set off by a very shallow furrow from the frontal glabellar lobe, showing a poorly defined rim, set off by an exceedingly shallow furrow, representing about one-third of the width of the palpebral lobe. Other cephalic parts not preserved. Length of glabella plus occipital ring 4-5 mm.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—The features of this species, as far as can be observed on the incomplete cephal, agree with *Olenellus*, but reference to other genera of the family cannot be excluded. The shape of glabella and palpebral lobe shows a marked resemblance to *Holmia kjerulfi* (Linnarsson).

Disposition of material.—Figured specimens: U.S.N.M. 146038.

Family DORYPYGIDAE Kobayashi, 1935

Genus *KOOTENIA* Walcott, 1889

Type species.—*Bathyriscus (Kootenia) dawsoni* Walcott.

KOOTENIA, species undetermined

Plate 12, figures 14, 15

Available material.—A single, incomplete pygidium.

Description.—Pygidium of relatively low convexity. Axis wide, moderately tapered, straight-sided, composed of six well-defined rings plus a terminal section, reaching the posterior border furrow. All

the axial rings except the last have a median node. Pleural regions in proximal portion not downsloping at all, convex and downsloping only in marginal portion. Five pairs of pleural furrows very broad and moderately deep; narrow interpleural furrows well defined especially in the proximal portion. Border furrow broad and poorly defined; border flat, extended into several pairs of spines of about equal size, evenly spaced, and directed perpendicularly to the margin. All spines are broken and their length cannot be ascertained; the bases of five pairs of spines are visible, but there must have been another pair on the anterior, unpreserved portion of the border. The distance between the spines of the sixth pair is much greater than the distance between successive pairs.

Surface of test with ornamentation that consists of shallow puncta on the axial rings and becomes rather of reticulate type on the pleural regions. Length of pygidium 6.0 mm, width 10 mm.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—This pygidium is referred to *Kootenia* which it resembles more than any other described genus, but its unusual features might suggest a new genus if the cephalic parts were known. Compared to the described forms of *Kootenia*, the axial rings are proportionately much wider and shorter, the pleural regions are flat rather than convex in their proximal portion, and the interpleural furrows are unusually developed. In particular, there is little resemblance to the species of *Kootenia* or *Fordaspis* described from the Lower Cambrian of the Taconic area (Lochman, 1956).

Disposition of material.—Figured specimen: U.S.N.M. 146039.

Genus BONNIA Walcott, 1916

Type species.—*Bathyurus parvulus* Billings.

Several species of *Bonnia* seem to be represented by cranidia, associated with one form of pygidium definitely referable to the genus. It cannot be determined whether all the cranidia belong to *Bonnia* rather than to *Kootenia*, since the two are not always generically distinguishable in the absence of the pygidium. For these reasons each cranidium is described as an undetermined species of *Bonnia* and the pygidium is not referred to any of the cranidia.

BONNIA, species undetermined No. 1

Plate 11, figures 23-25

Represented by several examples, mostly too immature for specific identification. Entire cranidium proportionately wide and short.

Glabella slightly expanded forward, with traces of lateral furrows. Occipital furrow deep laterally, shallow medially; occipital ring but partially preserved. Fixigenae convex and downsloping, about half the glabellar width. Ocular ridges low and broad, paralleling the border furrow. Border not well preserved, seemingly very narrow at least in front of the glabella. Palpebral lobes shorter than average for the genus; posterior area wider (tr.) than occipital ring. Surface of test with indistinct ornamentation. Length of largest cranidium 3.5 mm.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—This form cannot be identified with any of the species of *Bonnia* previously described, in particular with the numerous species illustrated by the writer from the conglomerates of Quebec (Rasetti, 1948). The chief characteristic is the breadth of the cranidium, the glabella and the fixigenae.

Disposition of material.—Figured specimens: U.S.N.M. 146040.

BONNIA, species undetermined No. 2

Plate 11, figure 22

Represented by an immature example. Cranidium of average shape for the genus. Glabella but slightly expanded, of average convexity, unfurrowed. Occipital furrow narrow but well impressed; occipital ring incomplete, possibly spinose. Fixigenae, palpebral lobes, and anterior border of average form. Length of cranidium 2.7 mm. Surface of test smooth.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—In the general proportions and lack of ornament this form might be compared with *Bonnia similis* Rasetti. As far as can be ascertained from one small, somewhat imperfect cranidium, it seems to differ in the more posterior position of the palpebral lobes.

Disposition of material.—Figured specimen: U.S.N.M. 146041.

BONNIA, species undetermined No. 3

Plate 12, figure 16

Possibly represented by a few, incomplete examples. The description is based on the best specimen illustrated herein. Glabella of average convexity, slightly expanded in posterior half, slightly tapered anteriorly, with but traces of lateral furrows. Occipital furrow wide and deep throughout; occipital ring long (sag.), extended into a short, somewhat blunt spine. Fixigenae relatively narrow; anterior border narrow in front of the glabella, wider laterally. Posterior area

not preserved. Test with shallow puncta, close together so that the ornamentation, which is not very conspicuous, might be described as intermediate between punctate and granulate; anterior border with irregular raised lines. Length of cranium 5.5 mm.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—This form might be compared with *Bonnia busa* (Walcott) which, however, has visible glabellar furrows and stronger ornamentation.

Disposition of material.—Figured specimen: U.S.N.M. 146042.

BONNIA, species undetermined No. 4

Plate 12, figure 18

Represented by a single, incomplete, somewhat deformed example. Glabella seemingly more convex both transversely and longitudinally than in the preceding form, although this feature may have been accentuated by slight lateral compression. Glabella on the average parallel-sided, with exceedingly shallow lateral furrows. Occipital furrow deep and broad; occipital ring incomplete, seemingly triangular and presumably spinose. Fixigenae incompletely preserved; anterior border of average width, strongly slanted backward laterally. Surface of test finely granulate, the granules on the posterior part of the glabella showing a tendency to become arranged in irregular, transverse ridges. Length of cranium 7.5 mm.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—The proportionately short and wide, strongly convex, nonexpanding glabella seem to distinguish this form from described species. It is quite possible that, were the pygidium known, this form should be referred to *Kootenia*. The cranium does not greatly differ from *Kootenia troyensis* Resser, as redescribed and figured by Lochman (1956), but no pygidia resembling that species were found in the collection.

Disposition of material.—Figured specimen: U.S.N.M. 146043.

BONNIA, undetermined pygidium

Plate 12, figure 17

Represented by a few examples, the only complete specimen being the one illustrated. Pygidium with relatively narrow, somewhat tapered axis showing three rings plus a terminal unsegmented section, reaching the border furrow. Pleural regions with four pairs of pleural furrows, counting the anterior border furrow, and but traces of one pair of interpleural furrows. Border furrow shallow, border flat,

seemingly lacking the small spine at the anterolateral angle. Ornamentation indistinct. Length of complete pygidium 2.8 mm, width 4.6 mm.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—This unmistakable pygidium of *Bonnia* presumably belongs to one of the cranidia described herein. It may be compared with the pygidium of *Bonnia senecta* (Billings) illustrated by the writer (Rasetti, 1948) which it resembles in the narrow axis and well-impressed pleural furrows.

Disposition of material.—Figured specimen: U.S.N.M. 146044.

FAMILY, GENUS, AND SPECIES UNDETERMINED

Undetermined pygidium No. 4

Plate 6, figures 20, 21

Available material.—Several incomplete examples.

Description.—Entire pygidium subtriangular, of moderate convexity. Axis well defined, somewhat tapered, straight-sided, almost reaching the posterior margin. Axial rings numerous, probably 13 or 14, all well defined by ring furrows that, at least in the anterior portion of the axis, show a median backward inflection. At least the first few rings seem to have borne a node or spine. Pleural regions downsloping, with straight, narrow, somewhat backward-directed pleural furrows that, at least for the first 10 segments, correspond to the ring furrows on the axis. About 11 or 12 pleural furrows are visible; there is no trace of interpleural furrows. All furrows end in a broad, poorly defined border furrow that sets off a narrow, somewhat convex border. The anterior outline of the pleural lobes shows a sharp geniculation very close to the axial furrow; past the geniculation the margin turns backward in a wide curve and finally assumes the straight backward and inward course that gives the pygidium a subtriangular shape. Surface of test smooth. The length of the largest pygidium, if complete, would be about 14 mm, the maximum width 12 mm.

Occurrence.—Collection cs-4, North Chatham.

Discussion.—This peculiar pygidium cannot be referred to any described genus of Cambrian trilobites, and not even a plausible family assignment is suggested. It is virtually certain that this is not the pygidium of an Olenellid or Ptychoparioid trilobite, and it seems unlikely that it belongs to one of the numerous Eodiscids present in the collection.

Disposition of material.—Figured specimens: U.S.N.M. 146000.

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EXPLANATION OF PLATES

GENERAL STATEMENT

To avoid unnecessary repetition, locality and collection numbers are only indicated for the few illustrated specimens that are not part of the writer's collection cs-4 from the North Chatham locality. Three specimens (pl. 7, fig. 18; pl. 9, figs. 14-16; pl. 11, figs. 6, 7) are from U.S.G.S. collection 4216 at the same locality. One specimen (pl. 5, figs. 13, 14) was collected near Elgin Station, Quebec, Canada.

All figured specimens show the outer surface of the test.

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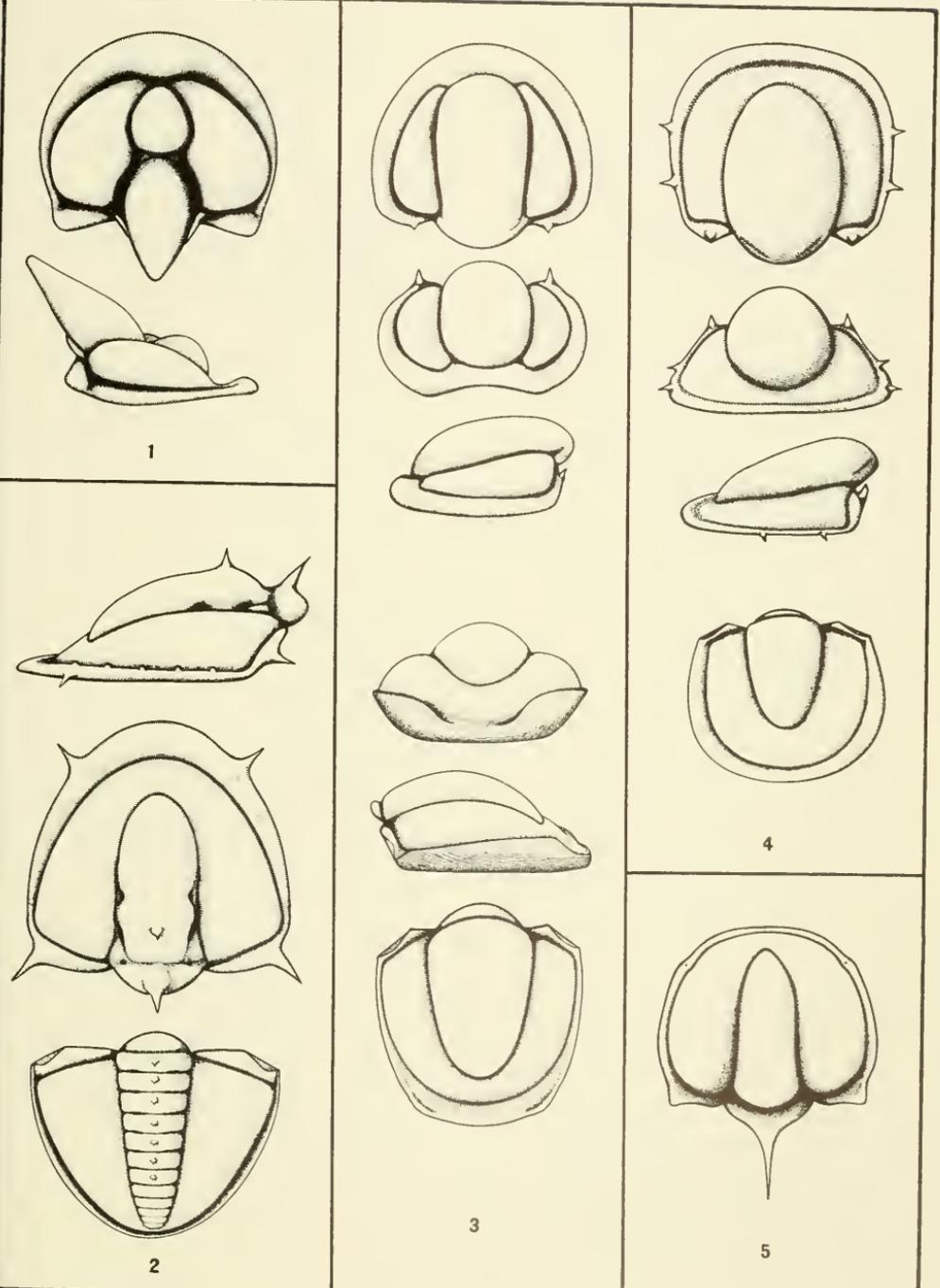
PLATE 11

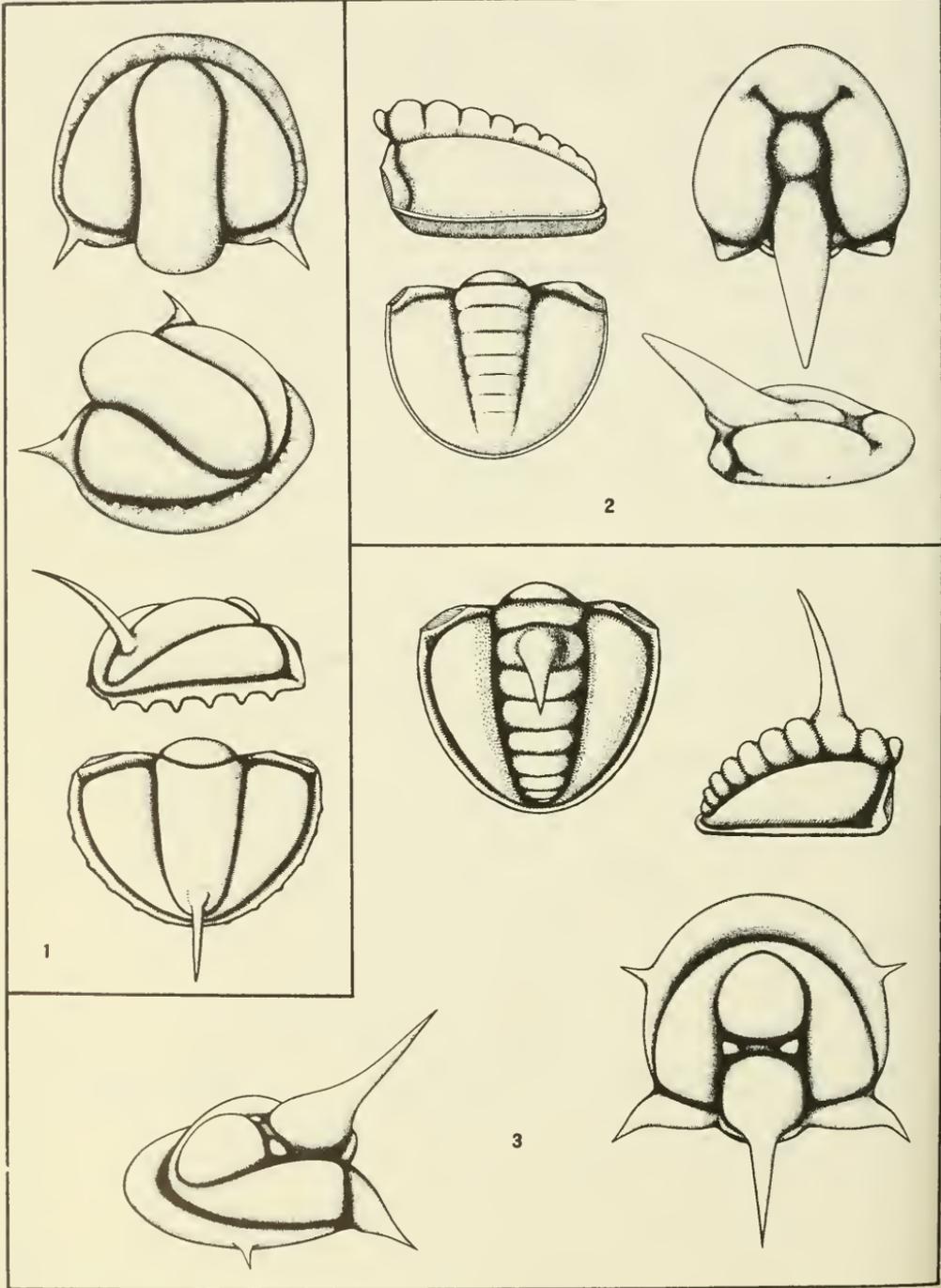
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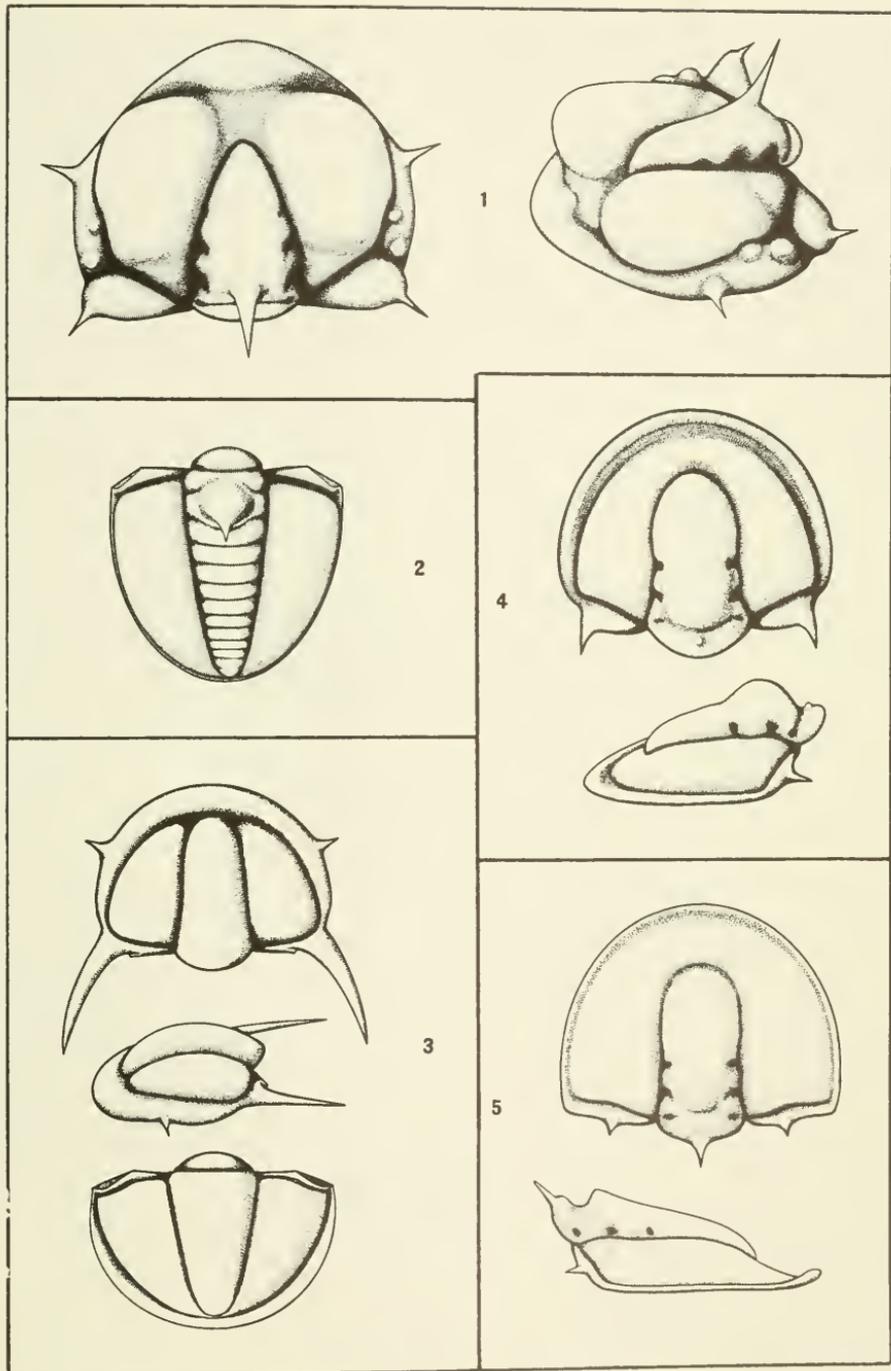
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Incomplete cephalon, $\times 5$. U.S.N.M. 146038.	
Figs. 23-25. <i>Paedeumias</i> , species undetermined No. 1	40
23, 24, Incomplete cephalon, $\times 5$. 25, Meraspid cephalon, $\times 15$, showing small procranial spines. U.S.N.M. 146036.	





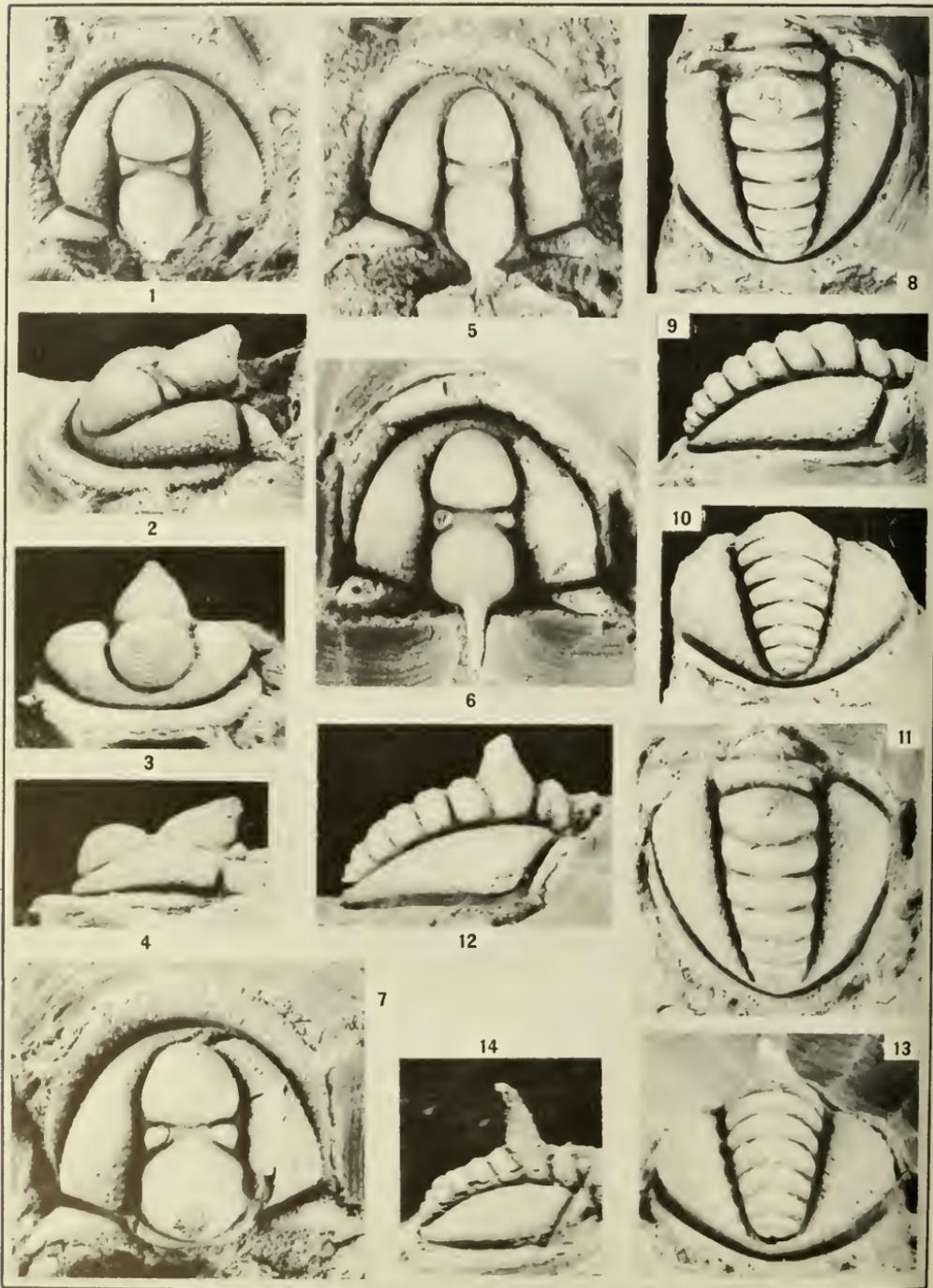
SERRODISCUS, ANALOX, ACIMETOPUS

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



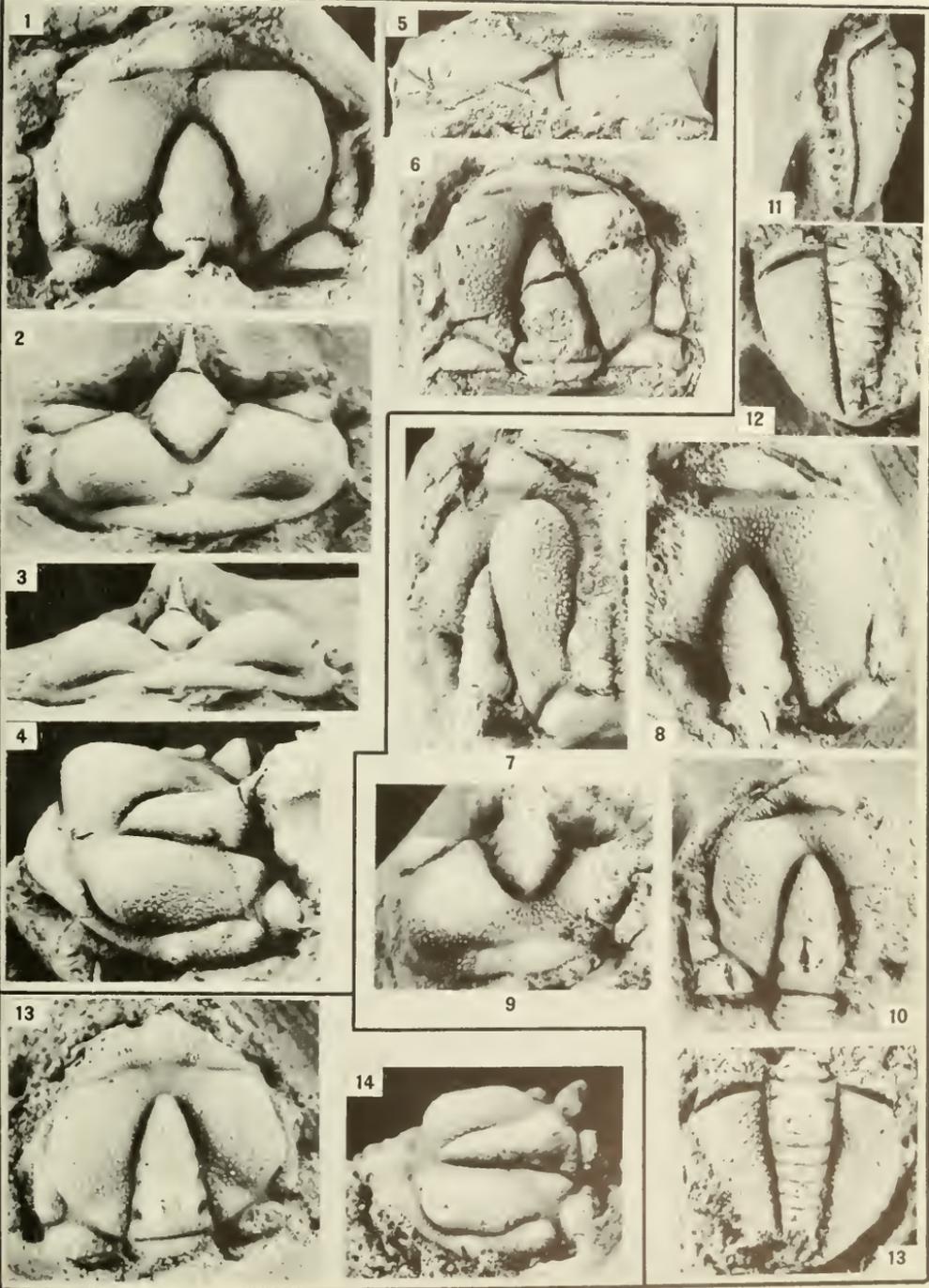
BOLBOPARIA, LITOMETOPUS, STIGMATISCUS

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



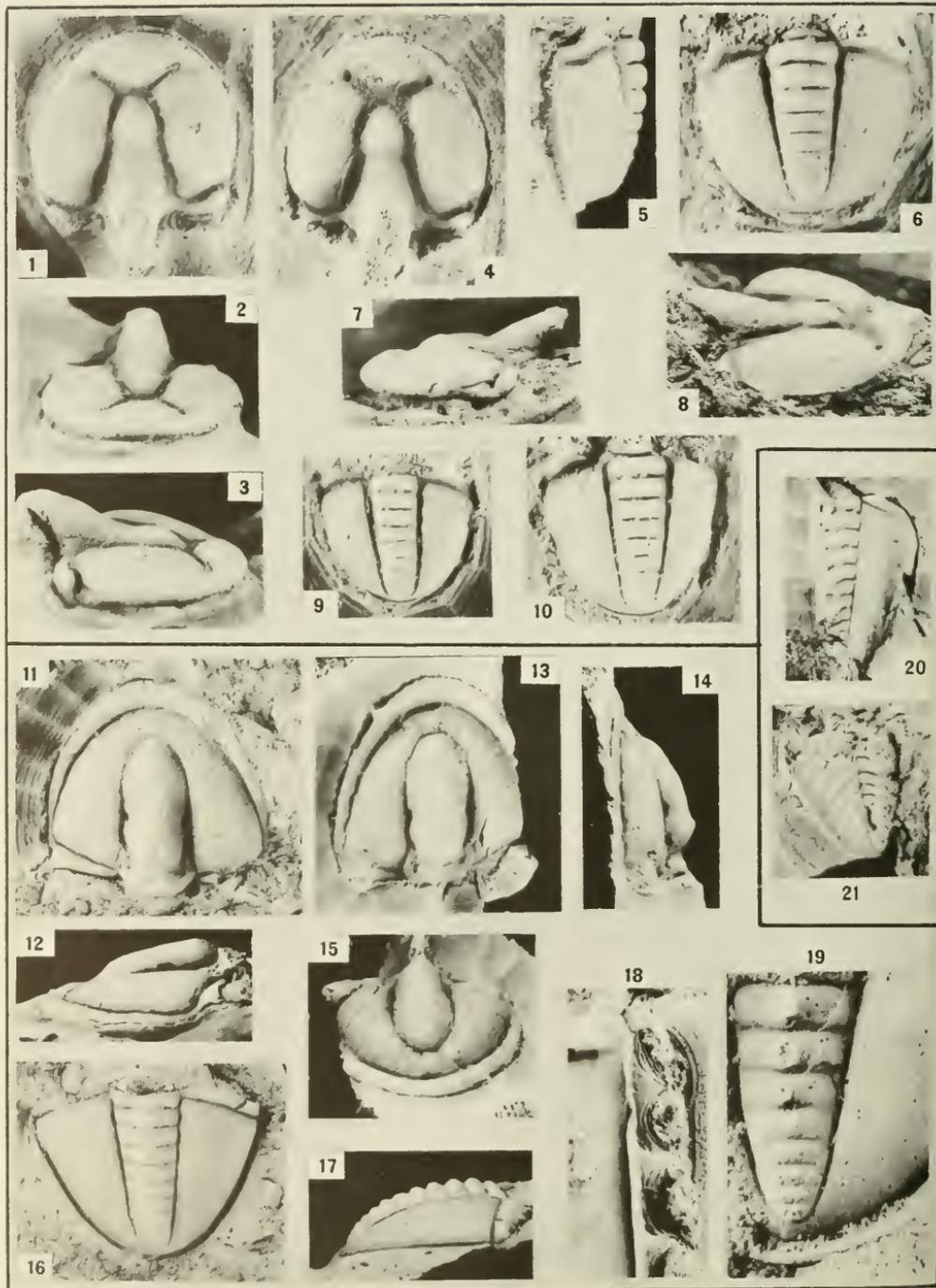
EODISCIDAE (ACIMETOPUS)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)

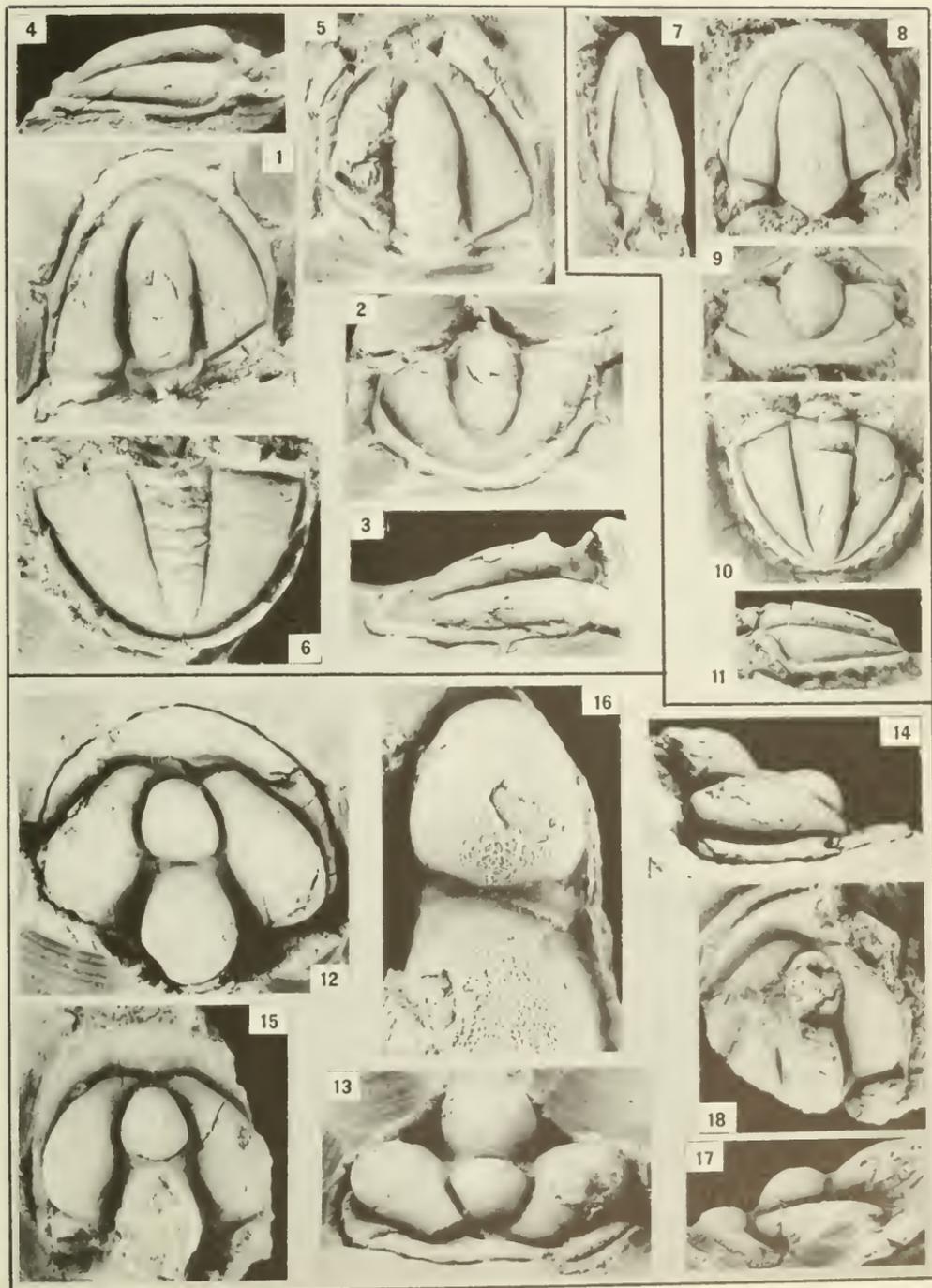


EODISCIDAE (BOLPARIA)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)

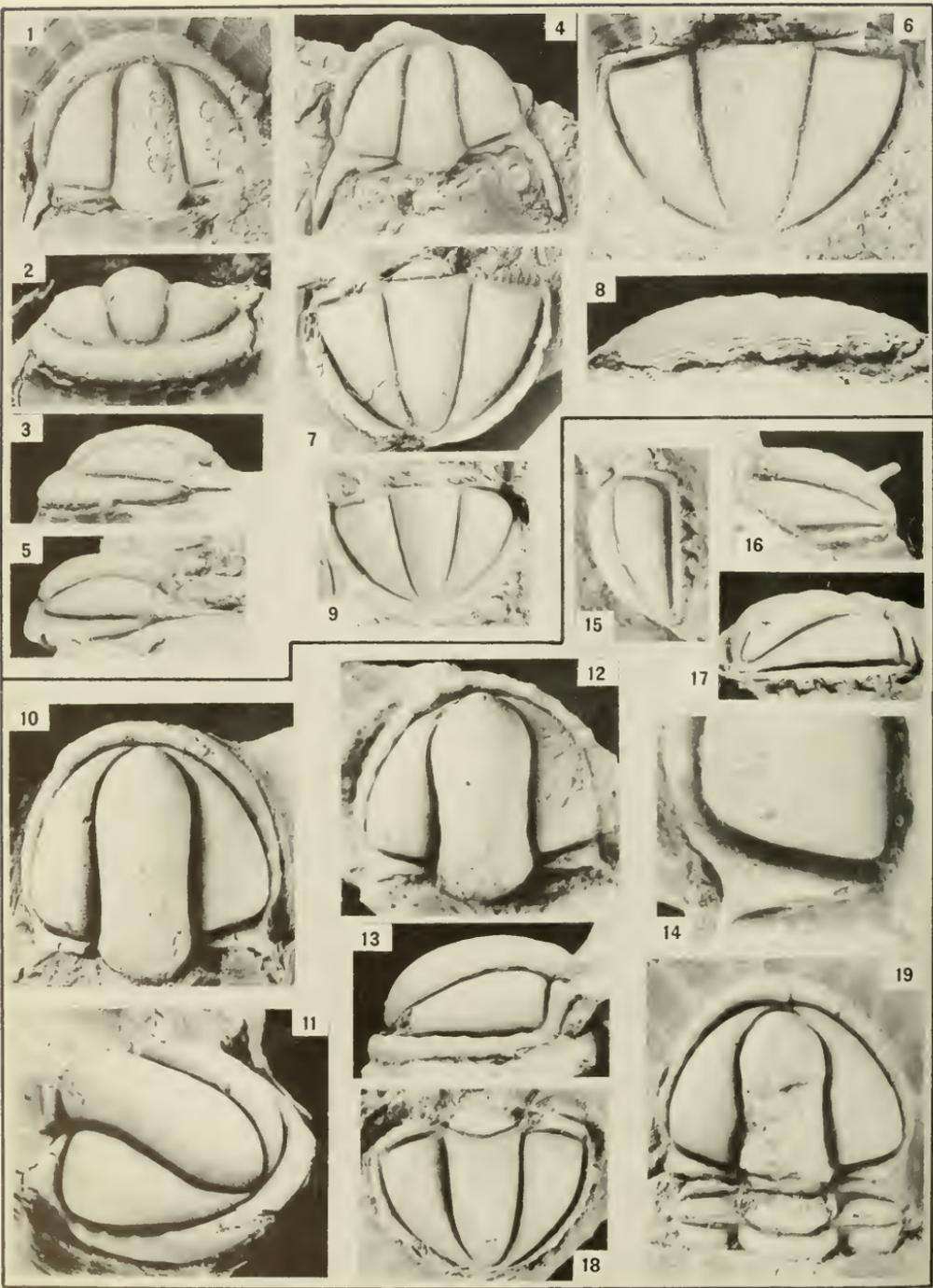


EODISCIDAE (ANALOX, ACIDISCUS); UNDETERMINED TRILOBITE
 (SEE EXPLANATION OF PLATES AT END OF TEXT.)



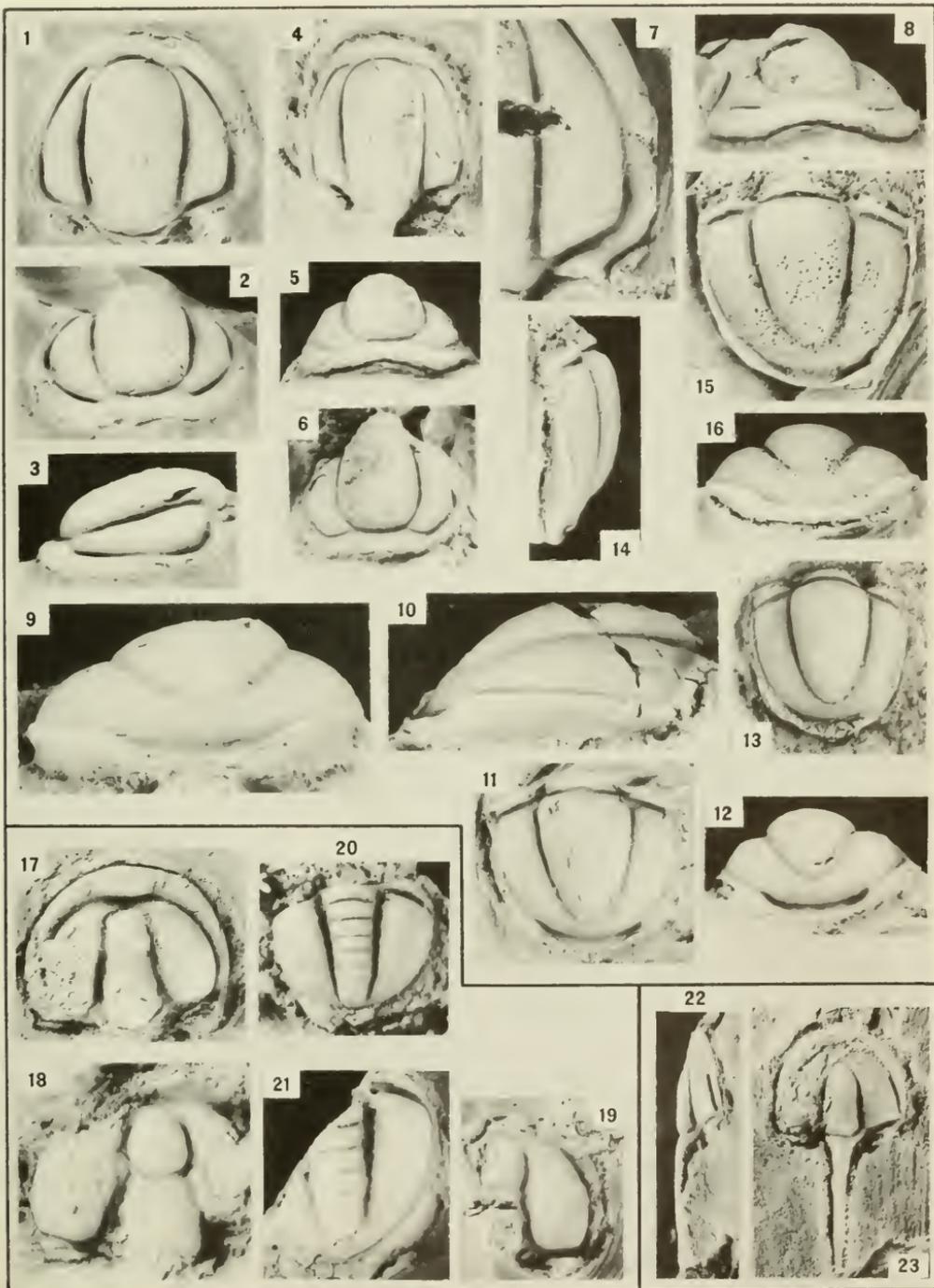
EODISCIDAE (ACIDISCUS, SERRODISCUS, CALODISCUS)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



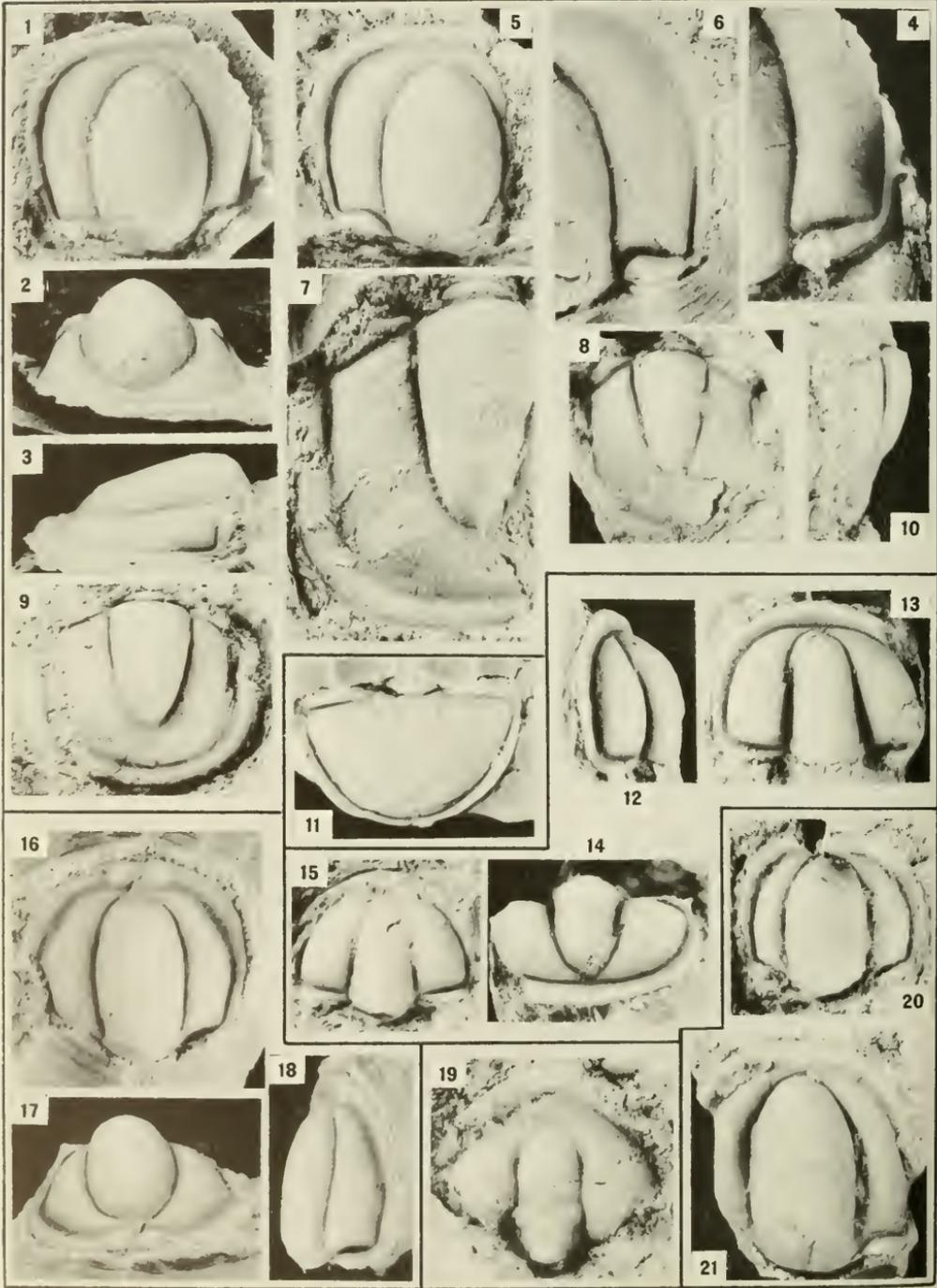
EODISCIDAE (LITOMETOPUS, SERRODISCUS)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



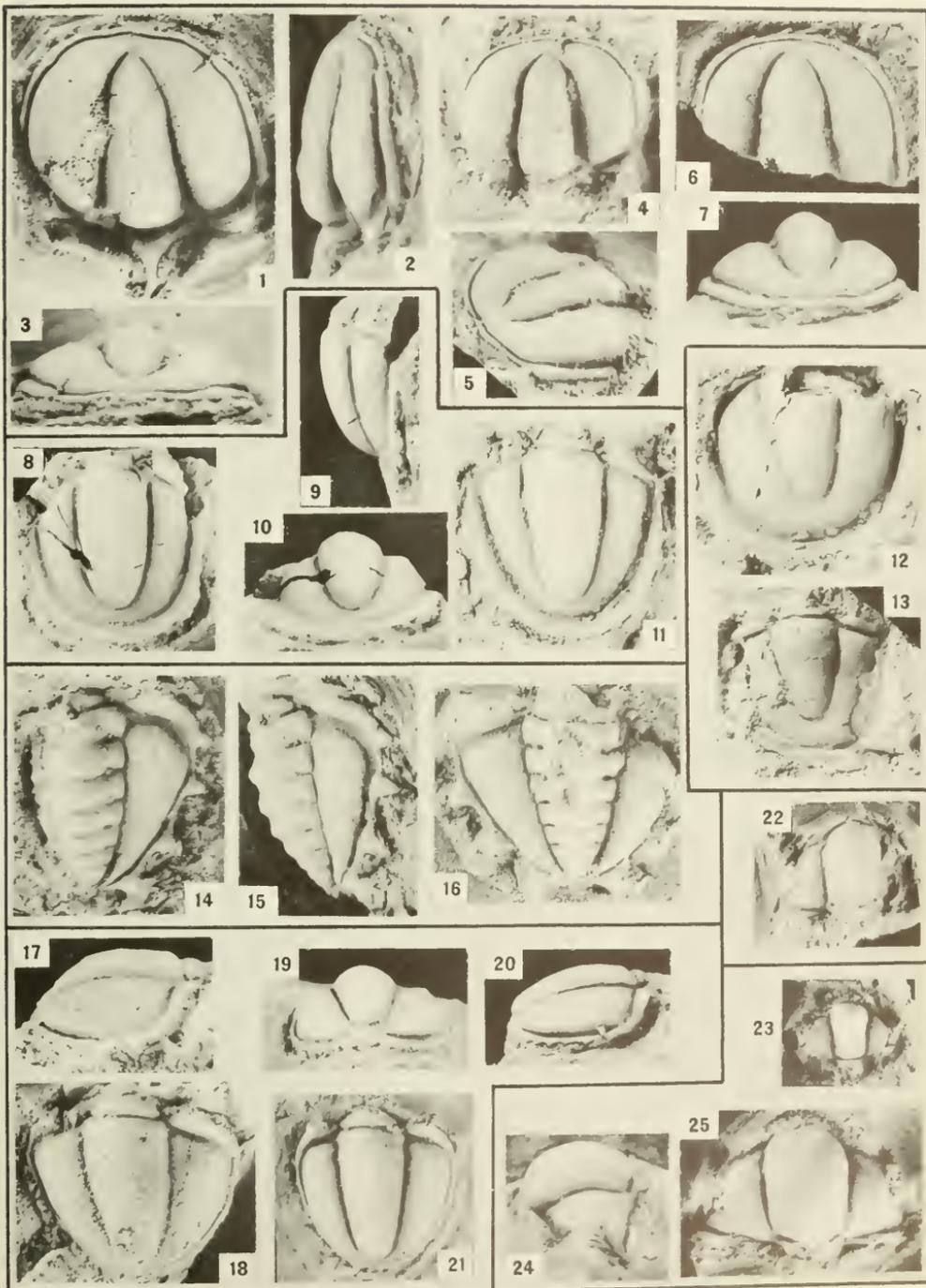
EODISCIDAE (BATHYDISCUS, CALODISCUS)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



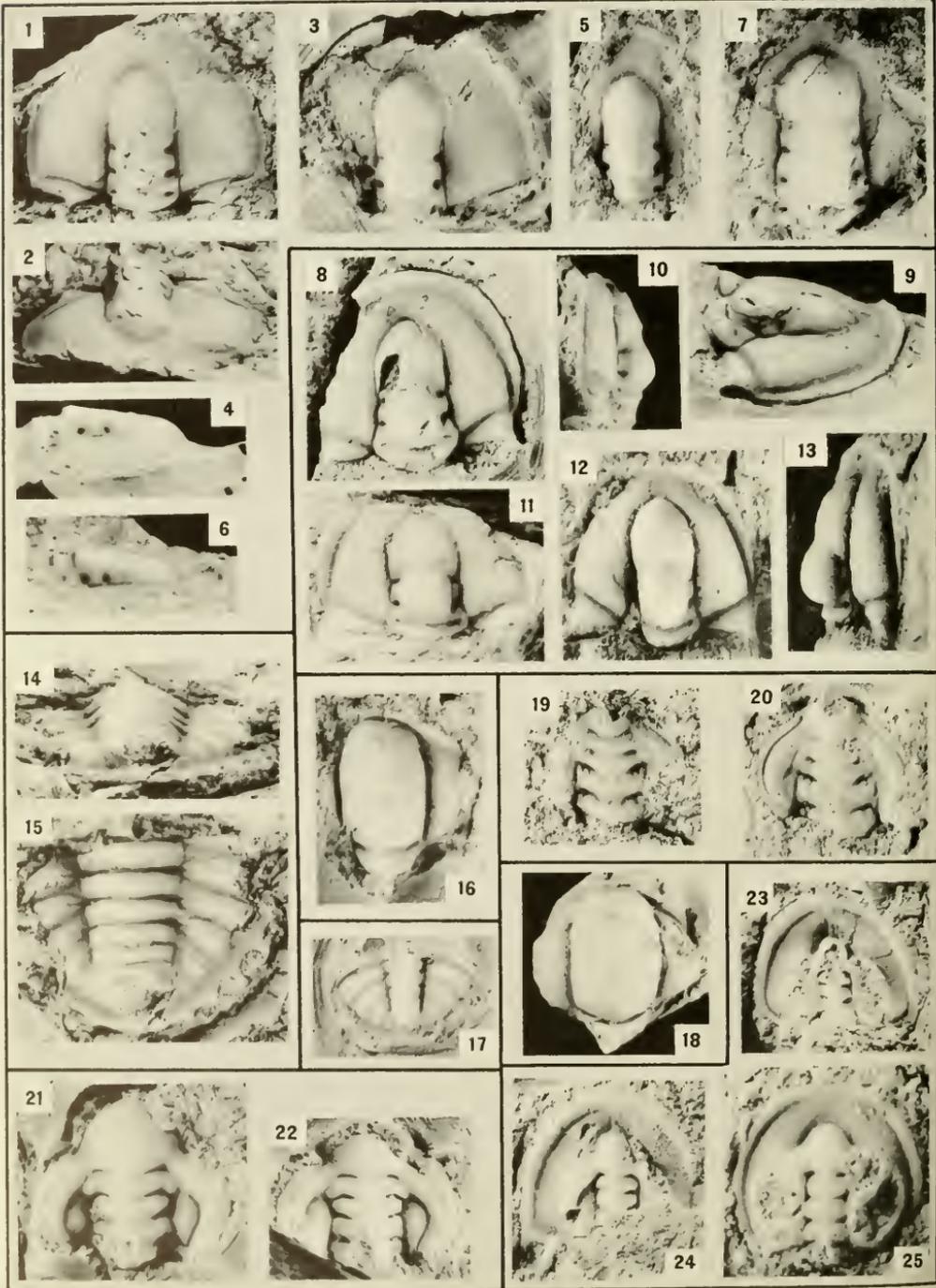
EODISCIDAE (OODISCUS, SERRODISCUS, UNDETERMINED GENUS)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



EODISCIDAE (LEPTOCHILODISCUS, OODISCUS, UNDETERMINED GENERA);
DORYPYGIDAE (BONNIA)

(SEE EXPLANATION OF PLATES AT END OF TEXT.)



EODISCIDAE (STIGMADISCUS); DORYPYGIDAE (BONNIA, KOOTENIA);
OLENELLIDAE (OLENELLUS, PAEDEUMIAS)

(SEE EXPLANATION OF PLATES AT END OF TEXT)